ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Vol. XLVII. No. 18.

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THE NAVAL PROGRAMME FOR 1903, as presented in the Naval Appropriation Bill, involves the expenditure of $77,659,386, or $442,404 less than last year. For the increase of the navy, provision is made for building two first-class battleships of 16,000 tons displacement, at $4,212,000 each exclusive of armor and armament; two first-class armored cruisers of 14,500 tons, at $4,659,000 each; and two 1,000-ton gunboats at a cost not exceeding $3,802,000. The report says that the 138 vessels of our new navy, built and building, cost $235,082,209; but out of this number our naval strength lies practically all in the 18 battleships, 8 armored cruisers and 21 protected cruisers. The bill leaves it discretionary with the Secretary of the Navy to build any or all of the new ships in government yards; but it requires him to build at least one in such yard and to keep a close account of cost for labor and materials, so that the cost by government work and by contract can be compared.

A NEW WIRELESS COMMUNICATION SYSTEM has been subjected to preliminary tests and taken up for further experimentation by the U. S. Weather Bureau and the Navy Department. The system has been worked out by Prof. R. A. Fessenden, of the Weather Bureau. It employs no coherer in the receiving apparatus, but has instead a so-called "wave-detector" which by means of an attached telephone renders the transmitted impulses audible. The principal point of advance over the systems hitherto brought out seems to be, according to news dispatches, the great reduction in the amount of energy required. A ¼-in. spark sent waves which could be legibly received at 50 miles; the Marconi system would require, it is said, a 2-in. spark for the same results. In the New York "Times" of April 28 Professor Fessenden is credited (?) with the statement: "I am absolutely certain that the ocean cables will shortly be taken up for junk."

AN EXPERIMENT AND TESTING STATION for fireproof materials and constructions is planned by a number of New England factory mutual insurance companies. The matter is being pushed by Mr. Edward Atkinson, President of the Boston Manufacturers' Mutual Fire Insurance Co. The purpose is to make tests and experiments on fireproofing of all kinds, so as "to enable the underwriters to deal intelligently with so-called fireproof construction." It is hinted that possibly the co-operation of the Massachusetts Institute of Technology may be secured, and the work of the laboratory thus carried on under scientific and trained guidance.

A STATE ELECTRICAL LABORATORY may soon be established in New York state. An act has been passed by the legislature which appoints Messrs. E. A. Bond, State Engineer; Charles P. Steinmetz, and H. W. Buck to constitute a commission

to investigate as to the necessity for the establishment of a state electrical laboratory to provide independent, authoritative information on questions of electrical science, and an official standardizing laboratory for electrical measuring instruments, apparatus and standards for the protection of municipalities and the general public in the use of electrical energy, and of the producers of electrical energy.

The sum of $2,500 is appropriated to cover the expenses of the commission. This body is to report to the legislature at the opening of the 1903 session, and its report, if in favor of the establishment of such a laboratory, is to include detailed plans and specifications for its construction and equipment, with a detailed estimate of cost.

THE PROPOSED ELECTROLYSIS SUIT at St. Paul, Minn., has at last been brought against the Twin City Rapid Transit Co. The water board asks for $500,000 damages to the water mains.

A MUNICIPAL ELECTRIC LIGHTING PLANT at Milwaukee, Wis., to be operated, possibly, in connection with the new garbage crematory, described in our issue of Jan. 23, 1902, is to be reported on by the city engineer by or before May 22. The estimates will include provision for 2,500 arc lamps of 2,000 c. p. each.

THE CONTRACT FOR COMPLETING THE BOONTON dam for the Jersey City water supply has been sublet to J. H. Quailey and Jas. F. McDonald & Co., for $676,198. Mr. Edlow S. Harrison, M. Am. Soc. C. E, of Jersey City, is Chief Engineer of the Jersey City Water Supply Co., and Mr. W. B. Fuller, of Paterson, N. J., is resident engineer. The detailed bids for this work were given on p. 159 of the Supplement of our issue of April 24.

AN AUSTRALIAN DREDGING CONTRACT is to be let, and proposals are invited for a date not yet announced. The work includes about 4,500,000 cu. yds. of dredging in limestone, sand and clay, and the construction of 1,500 lin. ft. of wharf and stone wall. The work is the building of an outer harbor in Light's Passage, entrance to Port Adelaide River. Plans and specifications will be on exhibition about May 15, at the office of the South Australian Agent General, 1 Crosby Square, London.

THE ROEBLING CONTRACT for the cables on the new Williamsburg bridge expired on April 21, and under the contract that company is liable to a penalty of $1,000 per day for every day beyond this date that the work is unfinished. The Roebling Co., through its attorney, has applied for an extension of time, until Sept. 30, 1902, upon grounds not made public. Meanwhile, the whole matter has been referred to Chief Engineer L. L. Buck and Engineer O. F. Nichols for investigation of the causes for the delay and to report to Bridge Commissioner Lindenthal.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Atchison, Topeka & Santa Fe Ry., near Cama, Mo., on April 29. An eastbound limited through train, going at a very high rate of speed to make up time, was derailed at a curve. The engine remained on the track, but the tender, two mail cars, the dining car, and the two forward sleeping cars out of seven, went into the ditch. The derailed cars were completely smashed. Four persons were killed in the wreck, and more than a score of others injured. The direct cause of the accident is not known; it is thought the rails spread.

THE BOILER OF A TUGBOAT EXPLODED in New York city on April 25. The tug "John Anson," lying at a pier in Newtown Creek, in the Greenpoint section of the Borough of Brooklyn, blew up and went to the bottom, early in the morning. The only person on board at the time was the fireman, who was killed in the accident. Several other persons, who were in the neighborhood at the time, were badly injured. The cause of the explosion is not known; it is believed that the fireman was at work getting up steam at the time. The boat went to the bottom of the creek, but her boiler was blown upward, striking against the wall of an adjoining building.

THE EAST SIDE BRANCH of the New York Rapid Transit Ry. Subway has been officially endorsed by the Rapid Transit Commission, and the Chief Engineer is ordered to prepare the plans. A rough estimate of cost is $15,000,000, and the proposed line would serve the people east of Central Park and in the eastern part of Harlem and the outlying district of the Bronx.

THE NEW YORK & NEW JERSEY RAILWAY CO., which is to finish the old Hudson River tunnel, has commenced work. It has received a loan of $7,000,000 on 30-year 5% gold bonds from the Guaranty Trust Co. of New York, and is already buying new machinery and plant and putting in order the New Jersey shaft, at the foot of 15th St. Mr. Charles M. Jacobs is Chief Engineer.

A ST. LAWRENCE RIVER TUNNEL, to connect Montreal and Longueuil, is proposed by a company now asking for incorporation. This tunnel would be in two separate sections, for railway and vehicle use, each tunnel to be 27 x 21 ft. in dimensions. These tunnels would be in rock, and both would pass under Ste. Helene Island in mid-stream. They would extend under the city to the railway stations.

THE NEWHOUSE MINING TUNNEL, starting at Idaho Springs, Clear Creek Co., Colorado, now shows a 12 x 12-ft. section, 12,861 ft. long. As projected it will eventually be about five miles long, ending under Quarts Hill in Central City, about 2,000 ft. below the surface. It is paid for by the Argo Tunnel & Mining Co., of London, and worked by a Colorado corporation. It is intended for drainage and development work. The present progress is about 160 ft. per month; the driving of 2,759½ ft. cost $79,478, or $28.80 per lin. ft.

THE SIMPLON TUNNEL, according to the progress report for March, now shows an excavation of 22,602 ft. on the north side, and 14,577 ft. on the south side, measured from the respective portals. At that time 2,844 men were employed, 2,037 working in the tunnel itself. The north heading is in uniform, shaly gneiss and micaceous schists, permitting a mean daily advance of 19.9 ft.; on the south side the advance is still through much contorted schist seamed with limestone, though veins of quartz are appearing. Water is troublesome on the south side, averaging a flow of 179 gallons per second, and necessitating an iron lining in bad ground.

A TUNNEL THROUGH SNOW has been contracted for by the County Commissioners of Ouray, Colo. An enormous snowslide blocked the road between Ouray and Red Mountain, and for a time the stage drove over the top of the slide. The warm weather has now softened the crust and made this transit impracticable—hence the tunnel proposed, which would be 300 ft. long, 15 ft. high, and have 90 ft. of snow over the roof.

STEAM TURBINES IN LARGE UNITS are to be supplied to the Metropolitan Railway Co. and the Metropolitan District Electric Traction Co., two of the London underground lines, for the operation of their central electric generating stations. These two lines have recently fought out a bitter struggle before a Parliamentary board of arbitration as to the system of electric traction to be adopted in the joint electric operation of both lines. The latter-named company, favoring the direct-current system of supply from converter substations fed by high-tension alternating current generated at a central station, won out, as against the three-phase motor system which has been developed by Ganz Bros., of Budapest, Austria. The current will be generated by three-phase alternators in units of 3,500 and 5,000 K-W., and these will be driven by Westinghouse-Parsons steam turbines. The constant service required of these latter, together with their great size, makes their adoption a matter of unusual importance. The results of the experience with the machines will be awaited with interest. The British Westinghouse Electric & Mfg. Co., of Manchester, are supplying the entire electrical equipment for both roads.

A FUEL ECONOMIZER to recover the heat lost in blowing up with the Lowe water gas process has been installed at the works of the New Haven, Conn., Gas Light Co. The apparatus was put in by the Green Fuel Economizer Co., of Matteawan, N. Y., which three years ago put in an economizer to do similar work in a small Lowe plant at the Poughkeepsie N. Y., gas works. The New Haven installation, however, is the first application of the system to a large works, the output here being about 2,000,000 cu. ft. per day

BY-PRODUCT COKE OVENS, built or under construction by the United Coke & Gas Co., now number 2,453, and have a combined charging capacity of 14,350 short tons per day. They are distributed among eleven plants and have all been built or put under construction since the beginning of 1895. The gas from seven of the plants is used for fuel; from three for illumination, and from one for both fuel and illumination. Three papers on the general subject of "Recent Developments in By-Product Coke Ovens," by Dr. F. Schniewind, of New York city; Mr. Thos. Littlehales, of Syracuse, N. Y., and Mr. C. W. Andrews, of Hamilton, O., were read before the recent meeting of the Ohio Gas Light Association. The papers were written more particularly from the viewpoint of gas works managers and may be found, with discussion, in "The American Gas Light Journal" for April 28, 1902.

AN AUTOMOBILE PARCELS SERVICE is an interesting new enterprise reported from England. The Manchester Motor Transport Co. will maintain a motor-car service to collect parcels and small freight, agricultural and dairy produce, etc., in and around the city of Manchester. The field covered by this service is one which is now worked exclusively by horse vehicles, though it is thought the service may be developed to take some of the short-haul business of the railways.

A DEPOSIT OF NATURAL COKE, in a vein 10 ft. thick, is being utilized by a mining company at Las Prietas, Sonora, Mexico. It is supposed to have been caused either by volcanic action or by surface conflagration.

THE COLORADO SPRINGS & CRIPPLE CREEK DISTRICT RAILWAY.

By W. P. Hardesty, C. E.*

The center of the Cripple Creek mining district in Colorado is, in an air line, less than 20 miles southwest of Colorado Springs, and is only 9 miles southwest of Pike's Peak. In 1891, attention was attracted to the district because of the rich gold discoveries which had been made, and each succeeding year since then has witnessed an increasing output of the precious metal from the Cripple Creek mines. At an early date in its history as a mining district, two railways, the Florence & Cripple Creek, from the south, and the Midland Terminal, from the north, were built to connect it with the outside world. These and some local roads were described in Engineering News of Sept. 8, 1898. In addition to these roads, it has been thought desirable for several years to make railway connection with Colorado Springs, which has always been the chief financial center for the mining enterprises of the district, and where connection was possible with some of the main lines of railway crossing the Rocky Mountains and the plains. The great obstacle to such a railway, however, has been the solid front presented by the Rampart Range (which includes Pike's Peak), on the western slope of which the district is located. After some effort a company was organized by Colorado Springs men, surveys were made, and consrtuction begun on a connecting railway. The distance by the railway from Colorado Springs (the initial point of mileage) to the summit of the range is 21.4 miles, and to Cameron Junction is 39.5 miles.

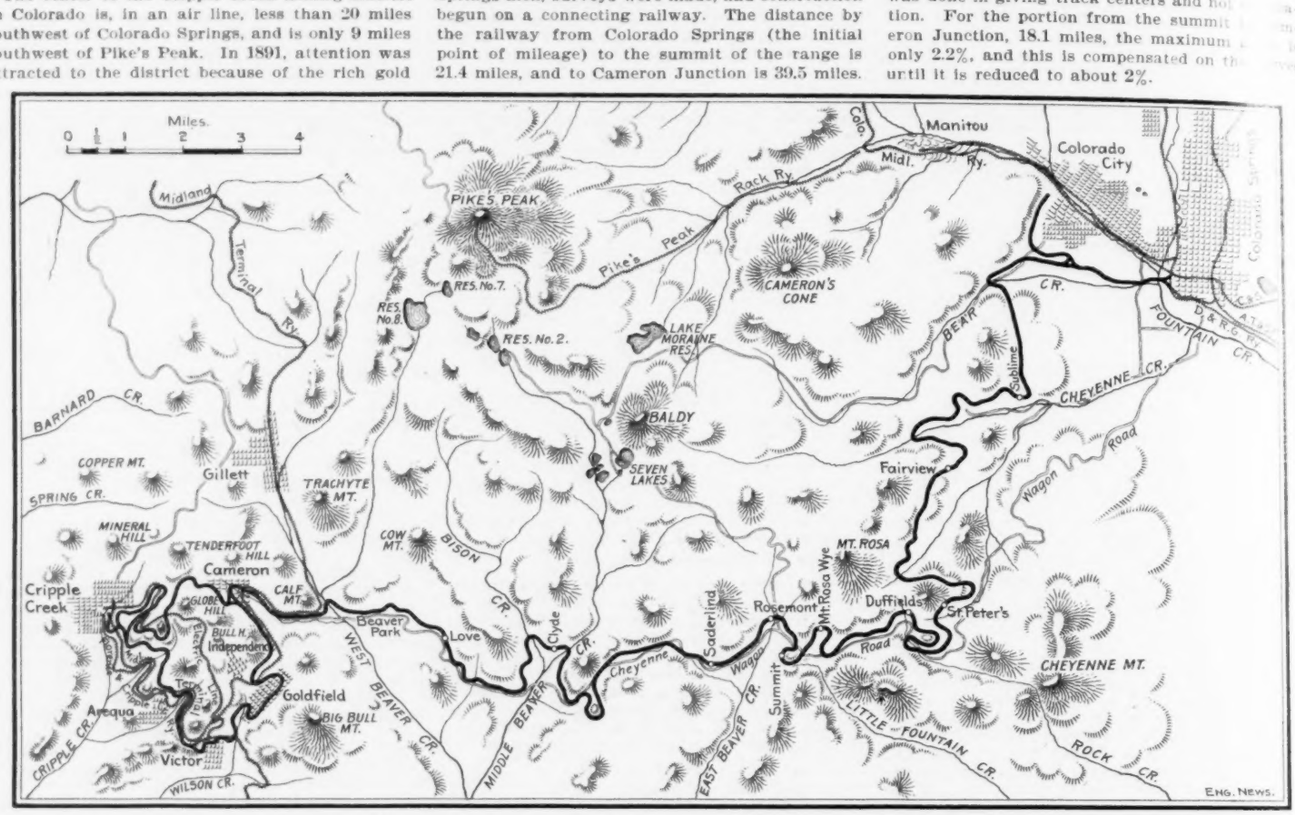
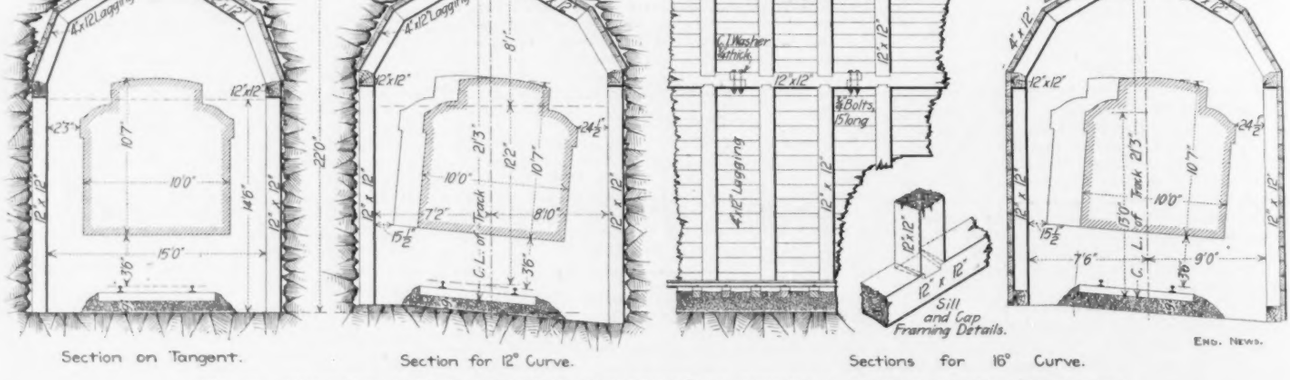


FIG. 1. MAP OF COLORADO SPRINGS & CRIPPLE CREEK DISTRICT RY., COLORADO.
T. L. Waggener, Colorado Springs, Colo., Chief Engineer.

At this junction the road forks. One branch leads to the city of Cripple Creek and the other to Victor. Mr. H. R. Carpenter, of Victor, is the chief engineer for these forks, and for the several spurs built to reach the different localities in the district. Mr. T. L. Waggener, of Colorado Springs, is the chief engineer for the main line as far west as the junction, and this will be described first.

EASTERN DIVISION.—The line starts from the Denver & Rio Grande Ry. depot, in the west part of the city, and, after crossing Fountain Creek, has a continuous grade of 3.8% all the way to the summit, compensated on curves at the rate of .03 per degree, so that the average grade is 3.56%. The rise to the summit is 3,958 ft.; the total rise to Cameron Junction is 4,993 ft., and the fall 713 ft.; 14,000 ft. of the grade is level. The highest elevation reached is 10,000 ft. The total curvature is 14,895°, and the average curvature per 100 ft. is 7° 8'. About 60% of the line is in curve. The sharpest curves are 16°, and the flattest are 3° 30'. Curves of 4° and over are spiraled. Much was done in giving track centers and notice to location. For the portion from the summit to Cameron Junction, 18.1 miles, the maximum grade is only 2.2%, and this is compensated on the curves until it is reduced to about 2%.

The line runs nearly west from Colorado Springs for about three miles, climbing the foot hills until it reaches the base of the main range. It then turns south and begins the ascent of this range. At Point Sublime, 6.6 miles, the road leaves the main slope fronting the plains on the east, and turns back into the canyon at North Cheyenne Creek. The mountain slopes are extremely rugged, and the difficulties presented to a successful development of line to reach the summit are unusually great. Dufflelds is reached at 18.1 miles, and from here the last view of the plains to the east is obtained. From the summit, 21.4 miles, a good view is had of Pueblo, 45 miles to the south. From here on to Cameron there is comparatively little change in elevation of the line, though much winding is required in running across the mountains. The range has a general slope or fall from



Section on Tangent. Section for 12° Curve. Sections for 16° Curve.

FIG. 2. STANDARD TUNNEL SECTIONS FOR COLORADO SPRINGS & CRIPPLE CREEK DISTRICT RY.

*Progress Building, Salt Lake City, Utah.

Pike's Peak to the south. Fig. 1 is a map of the railway.

The total excavation in grading for the line was 1,629,140 cu. yds., of which 80% was solid rock. The rock was all granite. Fills were built with a slope of 1¼ on 1. In excavation, solid rock was taken out at a slope of ¼ on 1; loose rock on a slope of ½ on 1; and earth on a slope of 1 on 1. In making fills with broken rock, much of it was lost by the large pieces rolling down the steep hillsides beyond where needed. For much of the solid rock excavation, the formation had some soapstone seams or strata dipping downhill or towards the roadbed, so that when the strata on the upper side were cut the blocks of granite

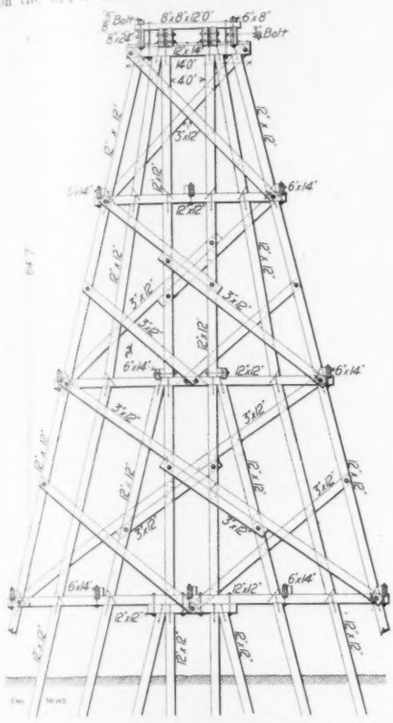


Fig. 3. Details of Bent for Standard Trestle, Colorado Springs & Cripple Creek District Ry.

would slide down from clear back where the soapstone seams met the surface. About 350,000 cu. yds. of extra material had to be moved on account of this. There was also some rock with seams of disintegrated granite that gave the same trouble. The longest cut on the line is 800 ft. long, with a maximum depth of 70 ft. on the center line; the largest fill is 300 ft. long, with a height of 50 ft. at the center.

There are nine tunnels on the line, ranging from 170 ft. to 521 ft. in length, with a total length of 2,404 ft. These run nearly entirely through solid granite, so that only a small proportion (probably 10% to 15%) of the total length had to be timbered. Tunnel No. 3 (in the tenth mile) gave the most trouble, the rock formation being soft from a point 2 to 3 ft. below the springing line up to the roof. It was timbered for 60 ft. in from the east end. Tunnels Nos. 6, 7, 8 and 9 were also timbered at the ends. On tangents, the clear section inside the timbers is 15 ft. wide and 20¼ ft. above top of rails, being 22 ft. high above subgrade; for 12° curves, the width is 16 ft., the center of the track here being 10 ins. outside of the center of the tunnel; for 16° curves, the width is figured for an 80-ft. Pullman car, and is 16½ ft., the track being 9 ins. out of center. This gives a minimum clearance of 15½ ins. at one bottom and one top corner of the car. On the curves, the superelevation given to the track also affects the cross-section to some extent.

For timbering, the posts, wall plates and five-segment arches were of 12 × 12-in. stuff; 4 × 12-in. lagging was used behind the arches, but none behind the posts. The backfilling behind the lagging was of cordwood. The timber bents were spaced 4 ft. c. to c. No sills were needed for the posts to rest on. The timbers were of Texas pine.

There are 31 timber trestles with a total length of 6,456 ft. They rest on either piles or concrete foundations. Fountain Creek, in Colorado Springs, is first crossed by a pile-bent bridge of eight spans of 32 ft. each. These spans have eight lines of 8 × 32-in. Oregon fir stringers, each 32 ft. long. The span for all the trestles is 20 ft. The drawings, Figs. 3 and 4, show the standard construction of the trestles, which are of unusual strength and security. The top bents or stories have six posts in place of the usual four posts, and the bracing is quite strong. There are six lines of 8 × 24-in. stringers, the pieces being 40 ft. long and breaking joints so as to make continuous chord stringers. The longest and highest trestle is that across West Beaver Creek, 2½ miles east of Cameron. This is 500 ft. long, and the height from the top of the concrete foundations to the base of the rail is 84 ft. Last May, by the breaking of the dam of a reservoir that stores water for the town of Victor, a flood came down the creek and washed out the concrete piers for two or three of the bents. Temporary timber supports had to be put in place of them. The trestles across Bear Creek and North and South Cheyenne creeks are also noteworthy structures. Nearly all the trestles are on curves.

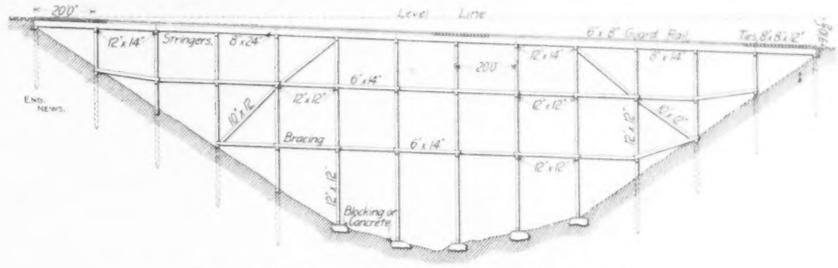


FIG. 5. SIDE ELEVATION OF STANDARD TRESTLE.

The track has ties of long-leaf Texas pine, 6 × 8 ins. × 8 ft., spaced 18 to a 30-ft. rail. The rails are 75-lb. steel. The elevation of rails on curves is figured for a speed of 25 miles an hour. For a 16° curve, this amounts to about 7 ins. The track is ballasted with disintegrated granite, obtained in abundance at points along the line. It is an excellent material, being composed of small, angular pieces of granite, and the track is quite solid and secure.

At 2.2 miles the branch to Colorado City leaves the main line. This is two miles long, and it reaches the great gold-reduction works of the Colorado-Philadelphia Reduction Co. and the Standard Milling & Smelting Co. These plants for the reduction of Cripple Creek ores have a combined capacity of 750 tons a day. A large smelter for the treatment of ores from the great Portland mine is being erected on the south side of the main road, not far from the junction of the branch. The supply of ore to these three works was one of the main objects in building the road.

The cost of the grading and track from Colorado Springs to Cameron averaged $43,500 per mile. The tenth mile, including Tunnel No. 3, was the most expensive, it costing $75,431 for the grading and about $2,500 for the two or three trestles. Construction was commenced Jan. 4, 1900, and completed Feb. 10, 1901. The line to Cripple Creek has been operated since April, 1901.

WESTERN DIVISION.—The Western Division, or the lines west of Cameron, includes nearly all the track in the mineral district. The standards of construction were much the same here as on the eastern or main division, and they fairly apply to both divisions. The length from Cameron to Cripple Creek City is 6.3 miles, and the line to Victor is 5.1 miles long. The latter line was not completed and put in operation until November, 1901. The maximum grade from Cameron to Cripple Creek is 3.8%, compensated. The maximum curvature is 16°. The track is elevated on curves for a speed of 20 miles per hour, or with a maximum elevation of about 4¾ ins. It may be noted that this is quite a contrast to the practice on the Midland Terminal R. R., nearby, which has an elevation of over 1 ft. on 16° curves, but the speed is quite high on this road at times.

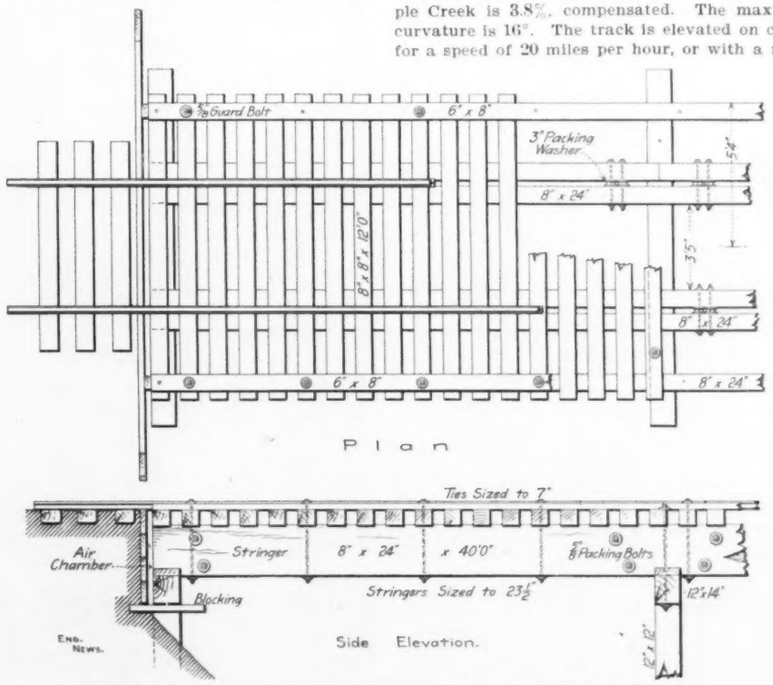


FIG. 4. DETAILS OF FLOOR SYSTEM FOR STANDARD TRESTLE.

The line to Cripple Creek goes over Hoosier Pass, and the one to Victor goes over Victor Pass. The following are some of the elevations of track: Cameron, 9,993 ft.; Hoosier Pass, 10,318 ft.; Crip-

ple Creek, 9,498 ft.; Victor Pass, 10,230 ft.; Victor, 9,714 ft.; and Midway (on the spur from Hoosier Pass), 10,500 ft.

The roadbed on fills is 14 ft. wide, and in cuts it is 18 ft. On the line to Victor there is a cut 90 ft. deep on the upper side, and containing 40,000 cu. yds. There is also a fill 50 ft. high on the lower side and containing nearly 50,000 cu. yds.

FIG. 6. VIEW OF TRESTLE ACROSS POVERTY GULCH ON COLORADO SPRINGS & CRIPPLE CREEK DISTRICT RY.

There was not nearly so large a percentage of solid rock in the grading west of Cameron as on the eastern division. In contracting the grading west of Cameron, the work was let at a flat rate of so much per cubic yard, without regard to classification, the bidder having to examine the formation beforehand in order to determine his bid. In this locality, the many excavations opened by mines and other railroads rendered this comparatively easy.

There are no tunnels on the line. The largest trestle is that crossing Poverty Gulch, in the northeast part of Cripple Creek (Fig. 5). This is 400 ft. long and 70 ft. high. The general plan of this is about the same as for the trestles on the eastern division. The track structure and caps are of Oregon fir; all below this of New Mexico pine. The view, Fig. 5, shows this trestle, and also the crossing under it of the "High Line" electric road, as the latter begins its ascent of the gulch. The steam road here makes a horseshoe loop, crossing the gulch again further up. On the branch to Victor there is a steel girder bridge of 48-ft. span, making an overhead crossing of the Midland Terminal R. R. on a skew.

The track is laid with about 1 ft. of disintegrated granite as ballast. The ties are of Texas pine, 7 × 8 ins. x 8 ft. The rails are 75-lb. steel, of the Am. Soc. C. E. section, spliced with four-bolt angle bars. The Q. & W. tie-plate is used on all curves. On sidings 60-lb. rails are used.

Besides the steam roads, the company also has two electric railways, connecting Cripple Creek and Victor. The first is the "High Line," described in Engineering News of Sept. 8, 1898. This runs over the top of the mountains between the two cities, and is the highest electric railway in the world. The second is the "Short Line" division, more recently built. This runs around the mountains, not very far from the steam roads of other companies. It has maximum curves of 26° and maximum grades of 4%, and is laid with 60-lb. rails. This Short Line is both an electric and a steam railway (60-ton engines are used for steam operation), but the latter use is not nearly so important as the use as an electric road for passengers, since the freight traffic between the two cities is almost entirely local and each has a branch from the main line at Cameron.

The present equipment and operation of the electric lines is as follows: On the Short Line three motor cars and three trailers are used. Each motor car is 42 ft. long, and its weight (including the motors) is 27 tons. There are four motors, one attached to each axle. They are General Electric No. 57, with K. 14 controllers, and each has a weight of 4,900 lbs. and a nominal HP. of 52½. Only motor cars are used on the High Line, and these are the same cars except for the air-brake part. The rated speed of an empty motor car up the 7% grade on the High Line is 12.6 miles per hour; on the 4% grades on the Short Line it is 22.5 miles. On the former line, the Christensen straight automatic air appliances are used, the reservoir pressure being 80 to 90 lbs., and the cylinder pressure 25 to 35 lbs. On the latter line, the Christensen automatic air appliances are used, the reservoir pressure being 70 to 85 lbs. and the train line pressure 65 to 75 lbs. The cars have a seating capacity of 44, though as many as one hundred and twenty-five passengers have been carried at one load. The motor cars have air whistles. The High Line has No. 00 trolley wire, and the other one No. 0000. There is a trolley at each end of a motor car, but only the rear one is used at a time, the front one being tied down.

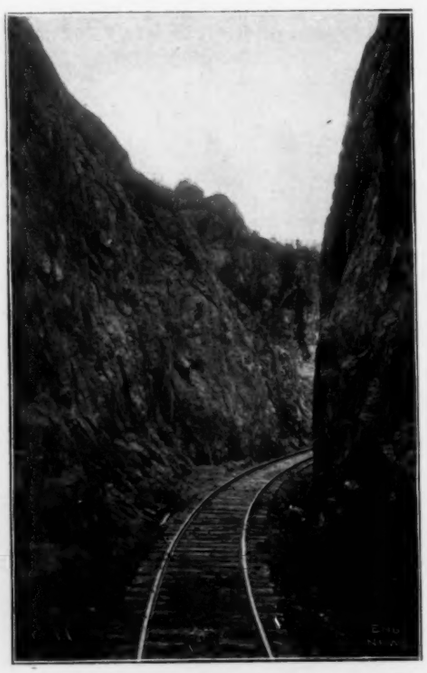


Fig. 7. "Tunnel Cut" on Colorado Springs & Cripple Creek District Ry.

The roads do considerable express as well as passenger business.

The electric roads have both water and steam power. The water-power plant is located at Lake Moraine, on the south slope of Pike's Peak. Water belonging to the Colorado Springs water supply system is used, being drawn from one of the reservoirs having a capacity of 2,500,000 gallons, at an altitude of over 11,000 ft. The fall secured is over 700 ft. in about one-half mile. The pressure pipe is 2,700 ft. long, and consists of 20-in. and 18-in. seamless steel tubing, the lengths being connected by cast-iron flanges with rubber gaskets. The pressure at the wheel is 318 lbs., and with a supply of 4½ second-feet the rated horsepower of the 36-in. Pelton wheel is 318 HP., running at 440 revolutions per minute. The water is delivered through a single nozzle of 2⅝ ins. diameter. There is a 16-in. water wheel for the exciter, with a nozzle 5-16-in. in diameter. The electricity is generated by a General Electric three-phase, 25-cycle machine, at a voltage of 6,600. The current is transmitted at this voltage to Cameron, 8½ miles distant. The transmission is over three of No. 3 bare copper wires. Here it is converted through static and rotary transformers to a direct-current of 600 volts, for use on the railways. The water power is supplemented by a steam plant at Cameron. From here the current is supplied to the two railways at different points.

In the locations of its lines in the mineral district, the company has found the obstacles interposed by man much more serious than the natural ones. Both the older roads had lines reaching to all the important towns and mines, and they strongly resisted any attempt of the newcomer to gain access to these points, or to make crossings of their own lines. In the end, however, the new road attained every end that it sought for, though at considerable extra expense. The company has several spurs to the larger mines of the district, the longest being from Lilly Junction to the Portland Mine, two miles long.

SUMMARY.—The rolling stock on October 1, 1991, consisted of seven road engines of 170,000 lbs. weight, and three switch engines of 135,000 lbs., all consolidation engines. They were built by the Schenectady Locomotive Works. The hauling capacity of one of the road engines up a 3.8% grade is 340 tons behind the tender, 7 loaded freight cars being the limit. There were also 24 passenger and 200 freight cars. The latter are also used for ore, and the freight traffic has been so heavy that additional cars have been ordered. The freight cars are 34 ft. long inside, have a weight of 32,000 lbs., and a capacity of 60,000 lbs. The road has been operated the past season with signal success, and a very large amount of both freight and passenger traffic has been handled. Four passenger trains each way per day have been ordinarily run, while during the tourist season as many as nine passenger trains in each direction have been run daily in July and August. Competent judges declare that nowhere else in America can there be found such a wealth and variety of scenery for the same length of road. Engineering skill of the highest order has been required to locate and build a road for successful operation, and the men who invested their means in the enterprise should be abundantly rewarded for their faith in the project.

A NORTH CAROLINA IRON WORKS OF 1777.

Among some old papers, there was recently found, by one of the editors of this journal, a voluminous manuscript report made in 1777 by one James Mills, Superintendent of "the furnace" in Chatham Co., N. C., to Archibald McLaine, Esq., "Commissioner of the Iron Works in Chatham County," New Bern, N. C.

The report is made to a provincial committee which had these works in charge. The furnace had been started at a previous visit of the committee, and pig-iron was made; but on Feb. 17 an unusual drought stopped the furnace "for Want of Water to Turn the Wheel." The first difficulty was encountered, however, at the first heating, and "before the Bellows Blew," from the melting of the stone used for lining the furnace; and work had to be stopped until a more durable hearthstone material was found in the neighborhood. A

stonecutter and two negroes, "Jemmy and Peter," were sent to quarry and cut the stone; but the superintendent could only secure one wagon to haul them to the furnace, and the owner would only undertake to haul one load, as "his Spring Crop is yet to be put in the ground." He adds, "I apprehend it will be supposed at Newbern that nothing can be more easy than to secure Waggons in Chatham, which is very far from being the

FIG. 8. ST. PETER'S DOME ON THE COLORADO SPRINGS & CRIPPLE CREEK DISTRICT RY.

Case at present. Many people justly lost their Waggons, having furnish'd the Tory Army with them last year." Even where wagons could be secured, the horses were wanting, as the few in the neighborhood were being used by the farmers. Mr. Mills sensibly advises the committee to purchase their own horses and wagons for the constant use of the works.

Mr. Mills was building a foundry "to cast potts & Shott, etc;" and he was also building another "near the Smith's Shop" for "Mr. Grelman to make his molds for Cannon." About a dozen "shott-flasks" were already made, and 18 more were to be framed. The models were being turned for cannon, 9-pdrs., 6-pdrs., 4-pdrs. and 3-pdrs., two of each. The writer of the report feared that "this shot-mold turning could not be done here, as the Spinning Wheel Turners cou'd only turn Round one way;" but he finally succeeded in finding a man who could "turn them truly spherical," and had eight patterns well turned.

His coal-house was 60 × 30 ft.; but the frame was still uncovered "for Want of Nails, which are not to be got." Another coal-house of similar dimensions is wanted; provided that "Capt. Rowan can get some nails for that and the Gun-Molding house now building." The negro smith made a few nails to make the flasks, "but he is so slow about it that he don't earn his Victuals at it; it is very Tedious Work, unless they have Nail Rods Ready Slit, of suitable Sizes." Further. Capt. Rowan says that those bought "come very Dear, and they were also a Bad sort, being sharp pointed."

Provisions for the workmen were another source of trouble. It seems that Congress ordered Capt. Rowan to buy corn and meat; but while "forty Hoggs" were available it was impossible to obtain salt to cure the meat. Mr. Mills finally secured "Eight Hundred Weight of meat at a shilling a pound," but it was scantily salted and little dried. He adds that, "as the house you ate in, & I lye in, is a most Excellent smoke house, or wou'd be so if it did not leak, I caused it to be hung in its Roof, where it will become Bacon, if smoak will make it so." He also bought 26 barrels of bacon at £6 per barrel, cost of hauling to be added. The corn he bought cost "13s. 4d. and fetch it."

In reporting upon the labor on hand, all negroes, he accounts for 4 men and 1 boy at the Forge; and he adds, as to the location of this forge, "last week, Capt. Rowan says he and Major Alston were fishing in it in a canoe, a Blessed place to make Barr Iron in, Especially as it is frequently so." At the furnace he had 13 men more, or 17 in all; and he also accounts for five women and six children engaged in cooking, helping, etc. Mr. Mills wants 20 to 30 negro men to properly carry on the work, besides wagons and horses; but he hopes, in a fortnight, to be again "in Order to Begin to cast Shott for the Defence of Our Country." He also expected to have a few guns cast in about six weeks, and was making ready to have "a Boring Wheel made & set up."

To support his claims for more men and supplies Mr. Mills soundly says,

> The means of our Defence shou'd be manufactured amongst us, and Consequently always at hand. This is obviously advantageous merely on acc't of our Safety; and when considered in a Commercial Light surely commands attention. As in order to be supplied with these Articles a Collection must be made of Our Gold & Silver, to be sent to God knows what Foreign Port to pay for them—if then to be had; without any Certainty of the vessel with Money, or Guns, &c, ever Riding at an Anchor again in any Port of this State.

He reports that "The Model of the Rolling & Slitting Mill (that the Provincial Council wrote to our Delegates to purchase from Mr. Whetcroft, at Elkridge) I have not heard anything of." But Mr. Mills thinks there is trouble enough on hand "without adding this mill this year." He was also informed that there was "plenty of Lyme stone for Flux" within 5 or 6 miles of the furnace, and now finds that he has to haul it upwards of 10 miles, and it is there "Dugg in but small quantities." To get this limestone, a horse and wagon is an absolute necessity. Mr. Mills had borrowed a horse, but "he is notorious for Running away," and as the place he ran to was four miles away, Mr. Mills did not think he "was fit for the use designed."

Mr. Mills reports upon the probable capacity of the furnace as follows: "The Furnace will run a Tonn of Metal, or near it, when in good Blast, with sufficient Flux, and this twice in 24 hours." He thinks that this metal cast into guns would be very valuable, especially, "when you advert to the price in Philadelphia, where the Iron Masters have £40 a Tonn for them deliver'd in the State House Yard." In Philadelphia, shot cost £25 per ton delivered at the same place, and the small shot cost more. This iron, converted into pots, etc., would bring 9d. per pound, and the same for bar-iron, says Mr. Mills; and as the Tories want the pots and ordinary castings, and are able to pay for them, he things that he could pay for provisions and some supplies from the local sale. The remainder of this long report is devoted to repeating the demand for supplies

AN EXAMINATION OF CANDIDATES FOR THE CORPS OF CIVIL ENGINEERS, U. S. NAVY.

Two vacancies in the Corps of Civil Engineers, U. S. Navy, have been created by the death of Captain C. C. Wolcott, in Brooklyn, on April 5, and by the resignation of Lieut. E. P. Goodrich, who has been on duty at the New York Navy Yard. These vacancies will be filled by a competitive examination to be held in Washington, D. C., beginning May 26. A circular stating the necessary qualifications and giving the scope of the examination has been issued, and copies can be obtained by addressing the Secretary of the Navy. The successful candidates will be commissioned officers in the U. S. Navy, with the rank of Lieutenant, Junior Grade. The salary for the first five years is $2,700 per annum. There is a bill pending before Congress for increasing the Corps of Civil Engineers of the Navy to 40, and its chances of passing during the present session of Congress are considered very favorable. It provides for the appointment of three additional Civil Engineers immediately and for three appointments being made next year, or in January, 1903. It is expected that the candidates who pass the examination to be held on May 26 would be eligible for these six additional appointments, in case Congress passes the bill that is now under consideration. It is therefore seen that there will be at least two appointments, and possibly eight, to be made from the candidates who successfully pass this examination. It is expected this will offer sufficient incentive to secure promising material among the candidates who will present themselves.

Candidates must be between 27 and 35 years of age, must pass a satisfactory physical examination, must be American citizens, must have received a degree in the civil engineering course of a reputable engineering school, must have had

FIG. 9. A BIRD'S-EYE VIEW OF CRIPPLE CREEK FROM THE C. S. & C. C. D. RY.

at least five years' practical experience in civil engineering, and at least three years in responsible charge of work. No candidate will be considered to have passed a satisfactory examination who does not attain a general average of 75% and an average of at least 80% in applied mathematics, constructional materials and engineering construction. We published in our issues of Jan. 27, 1898, and Jan. 19, 1899, sets of questions which have been used on previous examinations for entrance to the Corps of Civil Engineers, U. S. N. Below we print the questions which were used in the last examination, held in December, 1900:

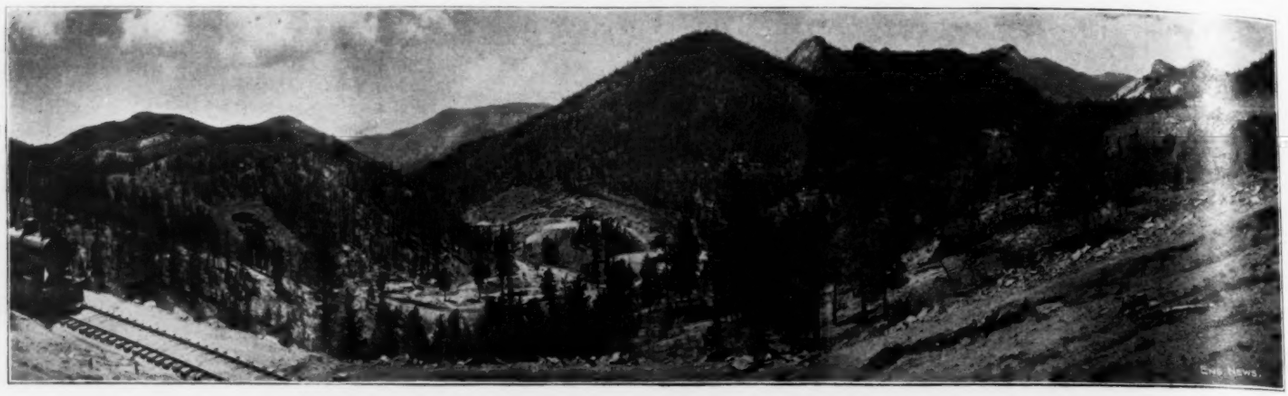


FIG. 10. A VIEW NEAR "DUFFIELDS;" C. S. & C. C. D. RY.

Examination Questions for Examination Held December, 1900, to Fill Vacancies in the Corps of Civil Engineers, U. S. Navy.

PERSONAL DATA

(a) Name in full. (b) Whether or not a citizen of the United States of America. (c) When and where born. Age in years and months on December 17, 1900. (d) Local address while taking examination. (e) Usual address, town, county and state. (f) Statement in detail of engineering education received. (g) Tabulated statement of positions held, time in each, detailed description of work.

DRAWING MATERIALS WHICH SHOULD BE BROUGHT IN BY CANDIDATES.

Drawing board, about 15 × 20 ins.; T-square; triangles, 30° and 45°; thumb tacks; a plain set of instruments; drawing pencils; mapping pens; red and black drawing inks; scales; drawing paper, white and detail, of each about 4 sq. ft.; tracing cloth, about 4 sq. ft. All drawings must be made to trim to 8½ × 14 ins., with a proper margin for binding.

ENGLISH COMPOSITION.

Write to the Board a letter about two pages in length, stating clearly and concisely what in your opinion is the most desirable branch of the civil engineering profession to be followed in civil life and why.

ENGLISH GRAMMAR.

1. Correct the following sentences if necessary and give reasons. (a) Were it true that a sufficient strata of clay exists at that level Smith and myself should have the information. (b) It is they whom our thoughtless friend would offend if he was present at the time. (c) To myself it has occurred that were he in a syndicate he would neither be so outspoken or so bitter in his opposition against such organizations. (d) Though he may try to impress on his auditors his own wide experience, he only succeeds in earning for himself the ridicule of those of even superficial education. (e) Well as he appear since his confinement with typhoid, he always complains of feeling badly.

2. Analyze the following sentence: Though he served or tried to serve Russia as faithfully as he had served America, the conditions he encountered were not adapted to his temperament.

3. Give a tabular synopsis of the voices, moods and tenses of verbs and illustrate by the first person singular of each of the following: Begin, get, eat, draw, bring.

4. State the rule for the usual formation of the plural of nouns and illustrate by three examples. State the plural of the following: Mouse, deer, man, woman, foot, swine, goose, vermin, box, cow, means, potato, wolf, ox, chimney, fairy, elf.

5. Classify and decline the following pronouns: I, whoever, that, you, it, myself.

ARITHMETIC.

1. Find the least common multiple of the following numbers, giving all work: 668304, 2100384, 12285.

2. Below are given the rod readings at the corners of 10-ft. squares taken over a portion of a borrow pit. Determine the amount excavated in cubic yards and also the side of a square bin 10 ft. deep which will just contain the excavated material. The rod readings are in feet.

10	6	3	2	7	4	5	10	6	7	3
4	4	5	6	3	7	5	6	4	5	4
7	3	6	10	12	7	9	10	5	2	
	6	8	16	20	25	12	8	4	6	
	5	8	5	13	24	14	6	7		
		4	2	9	11	7	3	5		
		10	6	4	3	5	6			
				5	2	4	8			

3. Find the partial and total feet, board measure, in the following bill of timber: 71 pieces 12 ins. × 14 ins. × 22 ft.; 16 pieces 12 ins. × 12 ins. × 30 ft.; 27 pieces 10 ins. × 12 ins. × 20 ft.; 116 pieces 6 ins. × 8 ins. × 18 ft.; 317 pieces 3 ins. × 14 ins. × 24 ft.; 18 pieces 3 ins. × 10 ins. × 22 ft.; 74 pieces 2 ins. × 8 ins. × 16 ft.; 506 pieces 1½ ins. × 12 ins. × 24 ft.; 117 pieces 1¼ ins. × 6 ins. × 16 ft.; 221 pieces 3 ins. × 4 ins. × 18 ft.

4. Determine the cube root of the following, giving all work: 67.825915363.

ALGEBRA.

1. Reduce to its lowest terms:

$$\frac{8\,a^2\,b^2 - 10\,a\,b^3 + 2\,b^4}{9\,a^4\,b - 9\,a^3\,b^2 + 3\,a^2\,b^3 - 3\,a\,b^4}$$

2. Find the value of:

$$\frac{b\,c\,d}{(a-b)\,(a-c)\,(a-d)} + \frac{c\,d\,a}{(b-c)\,(b-d)\,(b-a)} + \frac{d\,a\,b}{(c-d)\,(c-a)\,(c-b)} + \frac{a\,b\,c}{(d-a)\,(d-b)\,(d-c)}$$

3. Extract the cube root of:

$$27\,x^6 - 27\,x^5\,y - 45\,x^4\,y^2 + 35\,x^3\,y^3 + 30\,x^2\,y^4 - 12\,x\,y^5 - 8\,y^6.$$

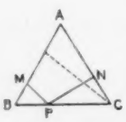
4. Solve the following equations:

$$3\,x^2 + 165 = 16\,x\,y \qquad 7\,x\,y + 3\,y^2 = 132$$

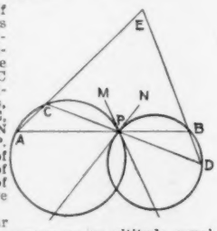
5. Expand to six terms:

$$\frac{1}{(2\,a - 3\,x)^3}$$

GEOMETRY.



1. If from a variable point P in the base of an isosceles triangle A B C, perpendiculars P M, P N to the sides are drawn, the sum of P M and P N is constant and equal to the perpendicular from C upon A B. See the subjoined figure.



2. Demonstrate that if through P, one of the points of intersection of two circumferences, any two secants A P B and C P D are drawn, the straight lines A C and B D joining the extremities of the secants, make a constant angle E, equal to the angle M P N formed by the tangents at P.

3. Find the lateral area of a frustum of a right cone of altitude 10, diameters of bases 8 and 12, and prove the formula used.

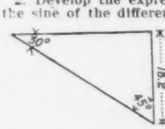
4. Prove that in a regular tetrahedron, three times the square on an altitude equals twice the square of an edge.

5. Define spherical excess and prove that a spherical triangle equals a lune whose angle is half the spherical excess on the triangle.

TRIGONOMETRY.

1. Express all the other trigonometric functions in terms of the sine and prove the expressions.

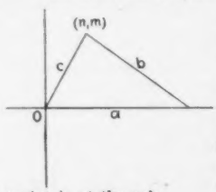
2. Develop the expressions for the sine of the sum and the sine of the difference of two angles. Also develop Sine (a + b + c).



3. Find the missing values of the angle and sides in the triangle shown and derive the formula used to obtain the sides.

4. Give Napier's rules of circular parts and illustrate the same by a diagram.

ANALYTICAL GEOMETRY AND CALCULUS.



1a. Find the equation of the straight line which passes through two given points.

1b. Demonstrate that the straight lines drawn from the angles of a triangle to the middle points of the opposite sides meet at a point. Use the subjoined figure and notation.

2. Deduce the general polar equation of the circle and show its form when the center is at the pole.

3. Demonstrate that from any external point two tangents can be drawn to an ellipse and determine the equation of the chord of contact.

4. Discuss by differential calculus the [illegible] represented by

$$y = \frac{a^2\,x}{a^2 + x^2}$$

5. Find by integration the area between the parabola

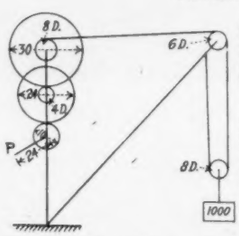
$$y^2 = ax$$

and the circle

$$y^2 = 4ax - x^2.$$

Show all work.

PHYSICS.



1. Neglecting friction, find the power to be applied at the end of the crank, and also the rate of hoisting the load when the crank is revolved four times per minute.

2. Draw a diagram of essential elements of a phonograph, describe the method of using the instrument, and give the principles upon which its operation depends.

3. Describe one of the more common forms of commercial ice machines, and give the principles and cycle of operations.

4. Describe the phenomena of the rainbow. Show when they may occur, and sketch a diagram showing the paths of rays of light from the sun to the eye of the observer.

5. Draw diagrams of a reflecting galvanometer and a Wheatstone bridge. Show how to use the instruments to find the resistance of a coil whose resistance is greater than the combined resistance of the bridge.

GEOLOGY.

1. What agencies are now at work to modify the structure of the earth crust? Explain the formation of soil. Why does soil accumulate more rapidly on lowlands than in mountainous regions?

2. State the origin of granite, quartz, clay, limestones, corals, sandstones, quartzite, coal, lignite.

3. What law governs the increase of erosive power with velocity in running streams? Give your authority.

What is an estuary? Give mode of formation.

What are faults? How caused? What is their effect in the exploitation of mines? Give illustrative diagrams.

4. Explain the origin of icebergs.

State the principal stratified building stones. What precautions should be taken in laying them in a structure?

What is the most common igneous rock used in construction?

What is the most common structure of basalt? What is the generally accepted cause of this formation?

5. What is the source of aluminum, its method of extraction, its principal alloy, its most notable characteristics, the principal drawbacks to its general use?

What is galena? Malachite?

What is the composition of hematite, magnetite, limonite, pyrites?

SURVEYING.

1. Find the area of the following piece of ground, determining the length of the missing course and also its bearing, giving the latter by means of its tangents:

a to b, N., 20 ft.; b to c, N. 60° E., 500 ft.; c to d, E., 300 ft.; d to e, S. 45° W., 400 ft.; e to f, S. 15° E., 400 ft.

2. Give day and night methods of determining the true meridian. State all instruments, tables, etc., required for the work, explain in detail the methods to be employed, and the corrections to be applied to observations.

Discuss the relation between magnetic and true meridians as to time and locality.

3. Give detailed description of the method of making a hydrographical survey of a tidal river at least 500 ft. across.

4. Given a level in perfect adjustment, describe in detail the method to be employed in running an accurate line of levels, several miles in length, over an irregular country. State the precautions to be taken and the corrections to be applied for climatic and other reasons.

5. Describe the method you would employ in making a topographical survey of a small area of great value to be improved at a cost which depends largely upon the conformation of the surface.

Describe the method you would employ in making a topographical survey of a large area of forest, swamp and lake, the value of the property being relatively small.

INSTRUMENTS.

1. Draw a diagram which shall show the principal features of a plain transit. Give the adjustments in order, describe them, and illustrate by diagrams.

2. Draw a diagram which shall show the principal features of a Y-level. Give the adjustments in order, describe them, and illustrate by diagrams.

3. Describe the stadia, illustrate by diagram, show its use, and deduce all formulæ needed for its operation.

4. Describe the construction and use of the surveying [illegible] and illustrate by diagram.

5. Show how the three-arm protractor is used in plotting [illegible] as determined by sextant angles.

6. Draw a diagram of a mercurial surveying barometer, showing all essential details for adjustment; describe [illegible] methods of transportation and use of instrument, and state what tables you would use in working up readings.

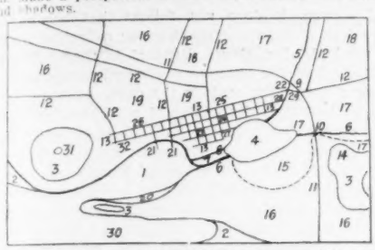
DRAWING.

1. Draw plan, one elevation and section parallel to vertical plane of the following:

A hexagonal block, with side 2 ins. and height the same, stands on the horizontal plane with its center 3½ ins. from the vertical plane. Through this block is a circular hole 1½ ins. in diameter. Standing with the center of its base to the left and in a direction from the center of the block which makes an angle of 30° with the vertical plane is a right cone with base 3 ins. in diameter and height 5 ins. Show shade lines, shades and shadows, the rays of light coming from the left and making an angle of 45° with both horizontal and vertical planes.

2. Make a finished tracing of the above drawing.

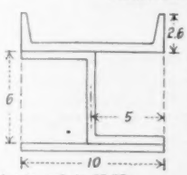
3. Make a perspective of the above blocks with shades and shadows.



4. Make a finished topographical map from the accompanying sketch. Reference numbers as follows:

1 bay.	13 streets.	24 court house.
2 sand.	14 quarry.	25 church.
3 hill.	15 swamp.	26 bl'ksmith's shop.
4 pond.	16 woods.	27 woolen mill.
5 creek.	17 grass.	28 sawmill.
6 river.	18 orchard.	29 grist mill.
7 canal.	19 cultivated land.	30 anchorage.
8 lock.	20 marsh.	31 light-house.
9 bridge	21 piers.	32 hotel.
10 drawbridge.	22 railroad station & telegraph office.	
11 railroad.		
12 roads.	23 postoffice.	

MECHANICS OF SOLIDS.



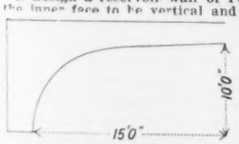
1. In the sketch shown the plate is ½-in. thick. The area of the 10-in. 15-lb. channel is 4.46 sq. ins. Its c. of g. is 0.639 in. from back of web. Its moment of inertia parallel to the web is 2.30 and perpendicular to web is 66.9. The area of the 6-in. 15.6-lb. Z-bar is 4.59 sq. ins. Its moment of inertia, neutral axis through c of g parallel to web, is 9.11 and perpendicular to web is 25.32.

Find the center of gravity of the combined section, its moment of inertia and radius of gyration about a pair of rectangular axes, parallel and perpendicular, respectively, to the web of the Z-bar and passing through the c of g of the section.

2. A medium steel shaft, 10 ft. long and 4 ins. diameter, has a gear wheel 6 ft. diameter keyed on one end. Using ordinary factors of safety for running shafting, what is the greatest horse power which can be transmitted? Give values for ultimate strength and safety factor used.

3. A standpipe, 80 ft. high and 30 ft. diameter, is constructed of soft steel plates, with lapped joints. What must be the thickness of the bottom course of side plates, using the customary values for the safe strength of the material? Seven-eighth-inch rivets being used, what must be the spacing of rivets in vertical seams in this course?

4. Design a reservoir wall of Portland cement concrete, the inner face to be vertical and the height to be 20 ft., the outer face to be uniformly battered; water level, 2 ft. below top.



5. Illustrate by means of the following diagram the method and principles of design of a stone arch, supplying any further lines necessary for the purpose.

MECHANICS OF FLUIDS.

1. Find the total pressure on the surface of a material cylinder of length 3 ft. and diameter 2 ft., its axis parallel to the surface of the water, in which it is immersed to a depth of 10 ins. from surface to axis.

2. Explain the turbine and impulse wheels; make a diagram of each and show when each should be used.

3. Give the formula for the flow of water through a pipe ¾ full and discuss it.

4. Let h be the total head on a pipe, h' the head lost in entrance, h'' that lost in friction, h''' that lost in valves, bends, etc.; deduce a formula for velocity and one for discharge from a circular pipe.

5. Derive and discuss the formula for the flow of water through a rectangular vertical orifice, its upper edge being coincident with the surface; a rectangular vertical orifice, its upper edge parallel to but below the surface of the water; a circular vertical orifice below the surface of the water.

PAVEMENTS.

1. Make sketches and describe in detail the design and construction of an asphalt paved residence street 120 ft. wide between house lines.

2. Make sketches and describe in detail the design and construction of a granite block paved street 50 ft. wide between store houses having the receiving and delivering doors on both sides of the same. Include a crossing.

3. Make sketches and describe in detail the design and construction of a brick paved street 80 ft. wide in a retail district, the street to have a double track for street cars. Width to be between store fronts.

4. Make sketches and describe in detail the design and construction of a macadam park drive 40 ft. wide.

5. Make sketches and describe in detail the design and construction of a gravel country road through a clay region, the road to be of small cost and sufficient for a small amount of traffic in heavy wagons.

BOILERS AND ENGINES.

1. Give the ordinary commercial rules for rating the horse-power of boilers.

What quantity of steam is required per horse-power per hour in the best quality of condensing engines of about 500 HP.?

2. Would a chimney 60 ft. high, having a flue 4 ft. in diameter, be equally good for anthracite and bituminous burning furnaces? If not, why not?

Give the essential features to be considered in the design of a furnace for the burning of anthracite coal and of one for a bituminous coal having a large percentage of volatile hydrocarbons.

3. Sketch the following different kinds of boilers: Return tubular, vertical fire tubular, water tubular, Scotch, locomotive.

State the advantages and disadvantages of each, describing, among other things, wrought iron, cast iron, cast steel, flowed steel and wrought steel, corrugated flues, straight tubes and curved tubes.

4. What elements should be included in the specification for an efficient 500-HP. cross-compound condensing engine direct-connected to two electric generators used for electric light service.

5. Make diagrams of and describe jet and surface condensers, give the advantages and disadvantages of each, state the auxiliary machinery required in connection with condensers, and state what you know of central condensers for a plant of several engines.

STRUCTURES.

1. Design a machine shop 300 ft. long and 90 ft. wide, walls 30 ft. high, benches and belted tools to be placed on the sides of the shop, the central bay to be a single story served by a traveling crane and having a railroad track and floor for heavy movable tools. Materials are to be steel, brick, wood, concrete and slate. Foundations supposed to be in a soil which will sustain 1,000 lbs. per sq. ft. at a depth of 1 ft. and 2,000 lbs. at a depth of 10 ft., water met at a depth of 5 ft. Weight of 250 lbs. per sq. ft. is to be provided for on the second floor and 500 lbs. per sq. ft. on the lower floor. Make free-hand sketches of plan, longitudinal and cross-sections.

2. Show full details of second floor using expanded metal or similar construction with fireproofed wood floor.

3. Show detail of floor in central bay to support work under construction and electrically driven movable 15-ton tools.

4. Show details of a double sash, check-rail, box frame window and the setting of the same in the side wall.

5. Show in detail and describe fully the construction of a tight skylight 6 ft. × 10 ft. in one side of the roof.

MASONRY AND FOUNDATIONS.

1. Discuss pile foundations in mud, quicksand and clay. Give rules for the determination of the bearing power of piles driven by ordinary pile-driver and by steam hammer. Under what conditions does each give best results? Why?

2. Under what conditions would you use screw piles and piles with disks? Describe the method you would use to put each kind in place. Design the screw end of an 8-in. steel pile to be placed in 30 ft. of water, seated in a sandy bottom, and to support 150,000 lbs.

3. Given a machine shop on compressible soil, to supply a foundation for a 15-ton steam hammer. Show how you would design the foundation without the use of wooden piles.

4. Give specification for laying best quality of stone masonry; also for a brick wall with ashlar front.

Show how terra cotta caps and lintels should be laid and secured.

5. Give specification for Portland cement concrete to be used for a building foundation. Give specification for the plastering of a room with regular three-coat work.

DRY-DOCK.

The site for a dry-dock having been selected and test piles driven, it is found from the latter that the penetration of the piles in the bottom of the dock will be about 40 ft. in sticky mud, the penetration under the last blow of a 3,000-lb. hammer falling 25 ft. being 1 in.

Sketch out, free-hand, a design for a concrete dry-dock with granite protective trimmings for all necessary points, the dock to be 600 ft. long on the floor from the gate-sill to first altar at head of dock, with a width sufficient for a battleship of 72 ft. 6 ins. beam. It is desirable to use due economy in the design, and to make the fullest use possible of the piles in conformity with good practice. A caisson gate will be used, but no details of it will be required.

MATERIALS OF CONSTRUCTION.

1. Describe fully the manufacture and characteristics of high-grade building brick, Roman brick, sewer brick and terra cotta tile.

2. Describe the difference between Rosendale and Portland concretes. Give the conditions under which you would use each kind.

What is the method you would employ to find the best proportions to be used in a concrete composed of broken stone, gravel, sand and cement?

3. In the case of a granite inverted arch resting on a heavy concrete bed in the bottom of a dry-dock, state how you would cut and bed each block.

Give a specification for high-grade roofing slate.

4. Describe by diagram the method of cutting quartered oak from logs; also edge grain flooring.

Give merchantable inspection for yellow pine boards and dimension lumber.

5. Describe the characteristics and give some of the principal uses for long-leaf yellow pine, lob-lolly, spruce, white pine, white oak, cypress.

6. Describe briefly the manufacture and characteristics of acid open-hearth steel, basic open-hearth steel, Bessemer steel and cast iron.

7. Describe in detail the manufacture by the open-hearth process of a modern structural shape, beginning with the taking of the ore from the mine.

8. Describe lead and zinc paints. Give the proper methods and proportions of mixing the manufactured article with oil and dryers for inside and for outside work.

9. Describe the best paints and other materials for use in protecting steel exposed to air and gases in a machine shop, in a water tower and trestle, and in a steel pier in a tideway.

10. Discuss slate, tin and copper for use as a roof covering. Describe the methods to be used in laying each kind. Give a specification for good roofing tin.

RAILROADS.

1. What is the degree of curvature of a railroad track? Show how a curve can be staked out by the method of tangents. Describe in detail the usual method of staking out 475 ft. of a 4° curve, starting at station 625-50, using a transit and a 100-ft. tape.

2. Describe in detail the method and work necessary to lay a side track from a main line already in place. Draw diagrams of plans and cross-sections of the parts.

3. How short radius can be safely used in yard tracks of 4.7 ft. gage? What limits the radius in this case? What is the best radius to use in industrial tracks of about 21 ins. gage as usually built in this country?

4. Make cross-sections of T and girder rails and discuss their advantages in street track work.

5. Indicate in detail the rolling stock necessary for a large navy yard, to include all necessities for the transportation of materials, for making general and special repairs, and for convenience and economy in all work which may be brought within reach of the track system.

WHARF.

Design a timber pile pier 80 ft. wide 600 ft. long for the dockage on both sides of ocean steamships. Depth of water at mean low water, 27 ft.; mean rise of tide, 4 ft.; bottom material, river mud to depth of 80 ft. Sketch details and main cross-sections of wharf, ready for commercial use. Give necessary formulæ used in the design.

QUAY WALL.

Design a quay wall to be built under the following conditions:

Mean rise and fall of tide, 5 ft.; extreme rise and fall, 9 ft.; bottom slope, about 1 to 8, running out to a depth of 32 ft. at extreme low water; character of bottom, 2 ft. of mud over sand and indurated gravel, into which wooden piles can be driven by impact less than 8 ft.; the water alongside the wharf to be at least 25 ft. deep at mean low water and 30 ft. at mean low water 15 ft. from the face of the wall; coping of the wall to be 5 ft. above mean high water.

The wall is to be of a permanent character, located in a semi-tropical climate, where the teredo is very active. The design is to include bollards.

WATER SUPPLY.

A town of 40 solidly built blocks, each block being 200 ft. wide and 400 ft. long and containing 32 4-story dwellings, is to be furnished with water from four non-flowing bored wells located outside of and one-quarter mile from one end of the town.

The town is located on a flat country, and is laid out in a rectangle four blocks wide and ten blocks long, with streets 60 ft. wide.

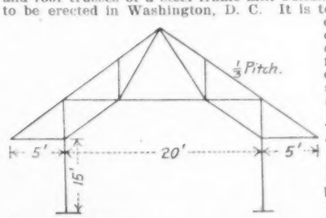
Design and lay out a complete water system from the wells to fire-plugs and house connections.

SEWER SYSTEM.

A tidal river flows beside one of the long sides of a town. The surface of the land is 2 ft. above extreme high water and 5 ft. above mean low water, the mean range of tide being 18 ins. Design a separate system of sewers for the above described town and include house connections.

STRAINS IN STRUCTURES.

The accompanying sketch shows the outline of columns and roof trusses of a steel frame mill building 47 ft. long, to be erected in Washington, D. C. It is to have double doors in the ends, single doors and box frame windows in the sides; its roof and sides to be covered with No. 22 corrugated galvanized steel. The columns are to be bolted down to concrete pedestals. In the ordinary way, and are continuous from ground to top chord of trusses.



Determine the frame for a proper dead load and snow load combined, and for a wind load of 30 lbs. per sq. ft. against a vertical plane, paying special attention to knee brace and columns. Show the purlins, side framing, etc., and show main details. Solve graphically and find stresses at one section analytically.

CRANE.

An electric traveling crane is to be installed in a new shop (not yet built), of which the span between outside flanges of columns is 50 ft. The capacity of the crane is to be 30 tons. Sketch out the arrangement of the crane as regards general details as to its construction and the design of the building as affected by the installation of the crane.

Briefly outline the calculations necessary to the design of the crane girders, defining the position of the load for the various maximum stresses.

CHIMNEY.

Using free-hand sketches, design a round brick chimney for a plant of 1,200 HP. on a good clay stratum.

Determine the center of pressure and direction of the resultant of forces using a horizontal wind pressure of 30 lbs. per sq. ft. and the usual weight per cubic foot for brick masonry.

ELECTRIC MACHINERY.

1. Give a diagram of a six-pole compound-wound, direct-current electric generator.

2. Give switchboard instruments and connections for two generators and six feeder circuits.

3. Describe the wiring of a three-wire system to use 110-volt lamps and 220-volt motors.

4. Describe open and enclosed arc lamps; state which is more economical and give the reasons.

5. In ordinary machine shop practice, where there are traveling cranes, would you use direct-current or alternating-current machines? Why? What are the principal conditions for best use of alternating current power plants?

ENGINEERING NEWS
AND
AMERICAN RAILWAY JOURNAL.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING COMPANY

GEO. H. FROST, - - - - - - - - - PRESIDENT.
D. McN. STAUFFER, - - - - - - - VICE-PRESIDENT.
CHARLES WHITING BAKER, SECRETARY AND MANAGING EDITOR.
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ALFRED E. KORNFELD, New York, M. C. ROBBINS, Chicago, S. B. READ, Boston. } ADVERTISING REPRESENTATIVES.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.
CLEVELAND OFFICE, OSBORN BUILDING.

FOREIGN AGENTS.

C. MITCHELL & Co, Snow Hill, Holborn Viaduct, LONDON.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES, & CIE. 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $7.90 (31 shillings); Thin Paper Edition, One Year, $6.31 (26 shillings). SINGLE COPIES of any number in current Volume, 15 cents.

In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 322 means that subscription is paid to the 32d week (that is the issue of Aug. 7) of the year 1902; the change of these figures is the only receipt, unless one is sent by special request.

ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The contrast between the spectacular and sensational and the solidly useful, and the unfortunate fact that the one often waxes fat and prospers, while the other, too often, appeals in vain for support, is well illustrated by two current items before us. One of these items states that a conference of "aerial experts" has decided upon a "figure 8" course over which the flights shall be made for the airship race at the St. Louis Exposition. The prizes in this race are to be $100,000 to the winner and $50,000 in subsidiary prizes. It is added that at least 150 airships are expected to compete. As an excellent commentary upon this item, we may quote the recent press dispatch which states that Count Zeppelin, who built some huge dirigible balloons near a Swiss lake a year or two ago, has been ruined financially by his expenditures, and is now breaking up the frames of his costly toys and selling them for scrap. It requires no very prophetic eye to see the finish of the flying machine inventors who may compete for the St. Louis prizes.

What we particularly wish to contrast with St Louis' prodigal expenditure of $150,000, however, is the announcement from Boston of the establishment of an experimental station under direction of the Factory Mutual Insurance Companies for the furtherance of the art of fire prevention and fire protection. It is hoped and expected that this will develop into a Department or School of Insurance Engineering at the Massachusetts Institute of Technology. Whether it does or not will depend upon whether the necessary funds are forthcoming. Subscriptions at the time the circular was issued had amounted to $3,000, all subscribed by owners of property insured in the Mutual companies, on the basis of one cent per hundred dollars of insurance carried. It is hoped to raise on this basis sufficient funds to make the department a possibility, and it is of interest to note that the sum estimated as necessary is $150,000, exactly the same amount that St. Louis proposes to spend upon the spectacular and sensational feats that have achieved wide notoriety because they served to amuse the "fast set" in Paris last season.

The movement to establish this experimental station for fire protection and prevention investigation has been started by Mr. Edward Atkinson, President of the Boston Manufacturers' Mutual Fire Insurance Co., who deserves large credit for his work in the field of fire prevention. The circular which he has issued* in announcement of his plan gives some interesting statistics of the fire loss of the United States, the great bulk of which could unquestionably be prevented by proper construction and proper methods of preventing fire risks and dangers. We have become too much accustomed in this country to look upon loss by fire as a necessary evil. The experience in foreign countries, and particularly the results achieved by the New England Mutual Insurance companies, show that the fire loss is merely a tax which we pay for ignorance and inefficiency. The average annual fire loss on miscellaneous risks in the United States averages from 50 to 60 cts. per $100 of value. The Mutual Insurance companies, covering chiefly cotton mill property, universally recognized as a most dangerous class of fire risks, have been able to reduce their rate of loss to only four or five cents per annum per $100 insured. Better proof that the bulk of the fire loss is preventable could hardly be given.

The matter of tests for fireproofed wood bids fair to be put on a much more satisfactory basis, thanks to the efforts of Mr. Perez M. Stewart, Superintendent of Buildings of the Borough of Manhattan, New York city, and his assistant, Mr. W. W. Ewing, Engineer of Tests of the Bureau of Buildings. The new New York building law requires fireproofed wood to be used in buildings over 12 stories in height, and also for the window frames of tenement houses, unless the frames are of metal or are metal covered.

The question soon came up, however, as to what was and was not fireproofed wood. With the demand for this material which the law created, a number of firms began the work of treating wood, and the need for some method of determining what should be required of fireproof wood became apparent. In the absence of some such standard, the tendency would be, of course, for competition to lower the quality of the product until it became fireproof in name only.

To discuss this matter, a meeting was called by Superintendent Stewart on March 20 of architects, engineers, builders, insurance and other experts and companies engaged in fireproofing wood. As the result of that meeting, two committees were appointed to prepare and formulate a standard test for fireproofed wood. One of these, known as the Working Committee, was made up of Prof. Ira H. Woolson, of Columbia University (author of the article published in our issue of Feb. 20), to have charge of fire tests; Prof. Collins P. Bliss, of New York University, to have charge of strength tests; Dr. Chas. F. McKenna, to have charge of chemical tests, and Mr. W. W. Ewing, Engineer of Tests of the Bureau of Buildings. In addition, an Advisory Committee was appointed, made up of a dozen or more experts, with whom the Working Committee will consult as to proper tests to be made.

A joint meeting of these two committees was held on April 22, and a schedule of tests was adopted to be conducted by the Working Committee. These tests, which cover a wide range, are to be carried out on a number of varieties of wood treated by the different processes on the market. At the conclusion of these tests it is hoped that some one simple test can be selected from among the number and adopted as the standard. If this can be done, the maker of fireproofed wood will know what requirement he has to meet and can adjust his chemicals and the amount of impregnation accordingly. The purchaser of such wood and his architect can determine whether they are receiving what they pay for, and finally, most important of all, the Inspectors of the Building Department can determine that the spirit of the law, which required the use of this wood as a means of retarding the spread of fire and protecting life and property, is being carried into effect.

*Copies can doubtless be obtained by addressing Mr. Atkinson at 31 Milk St., Boston.

IMPROVED METHODS OF GARBAGE DISPOSAL IN THE UNITED STATES.

The stubbornness with which most American communities cling to primitive and unsanitary methods of garbage disposal is shown by the fact that only 97 of the 1,524 cities and towns in the United States included in "The Municipal Year Book" have reported either garbage cremation or reduction plants. Moreover, these plants are located in only 28 of the 51 States and Territories which comprise the Union, while 9 of these 28 States report only one plant each.

Of course, it does not follow that because a place has neither a crematory or reduction plant its method of garbage disposal is therefore unsanitary, but the chances are, particularly in the larger places, that such is the case.

In collecting information for "The Municipal Year Book," an attempt was made to learn the final disposition of the garbage of every place of 3,000 inhabitants in the United States. Many of the reports were so indefinite as to render impracticable a summary for all methods and places. The most common method of disposal, however, is to dump garbage on vacant land, with more or less, and generally less, pretence of covering it. Frequently the reports stated that the garbage was buried, or used as fertilizer, or fed to hogs. Occasionally it is dumped in some convenient river or other body of water. In 107 cities and towns the reports stated that the garbage was burned. Doubtless, a few of these places have garbage crematories, but neither the reports to "The Municipal Year Book," nor information on the subject collected by Engineering News for a number of years past, indicate that the burning is done in garbage furnaces. In fact, there is good reason to believe that the material burned is not garbage at all, but merely paper and other more or less light, inflammable rubbish, which is burned in the open air. To help settle this point the names of the places which reported their garbage burned are given in a separate list herewith, in the hope that interested readers will correct and supplement the information now at hand.

The accompanying table gives the names and populations of the 97 municipalities reporting cremation or reduction plants, and states, also, which method of disposal is in use. Pennsylvania and Indiana lead in the total number of plants, having 14 and 12, respectively, and also lead in the number of crematories, which is 10 for each. New York, Pennsylvania and Ohio each report four reduction plants.

The 97 plants are distributed among four classes of population, as follows: Places with over 30,000 have 57 plants; 10,000 to 30,000 have 26; 5,000 to 10,000 have 11; 3,000 to 5,000 have 3. In the 38 cities of the United States which have populations of over 100,000 there are 15 with reduction plants, 6 with crematories, and 17 which employ such miscellaneous methods of disposal as dumping on land or in water, or feeding it to hogs. At Worcester, Mass., the hogs in question are owned by the city. The actual methods of disposal in vogue in these 17 places of 100,000 population and upwards are as follows:

Chicago, Ill., dumped, except very small portion cremated; Baltimore, Md., not given; New Orleans, La., dumped into Mississippi River; Newark, N. J., used for filling or dumped; Jersey City, N. J., used for filling; Providence, R. I., used as fertilizer; Kansas City, Mo., dumped into river; St. Paul, Minn., dumped; Rochester, N. Y., used as fertilizer; Denver, Colo., fed to hogs; Toledo, O., used as fertilizer or dumped; Worcester, Mass., fed to hogs owned by city; New Haven, Conn., not given; Fall River, Mass., fed to hogs; Saint Joseph, Mo., dumped into river; Omaha, Neb., not given; Los Angeles, Cal., burned.

It will be noted that Chicago appears in both the list just given and in the table. It is included in the table merely for the sake of bringing all the improved disposal plants together, however small they may be. There are other places where the disposal works are more or less inadequate for the total population, but it is impossible to specify them in every case, or to give any indication, for most places, of the adequacy of the plants in capacity. As to the sanitary or economic efficiency of any of the plants, nothing can be said in this place. The present object is merely to show the distribution of the works, both geographically and by sizes of the towns, and whether cremation or reduction is employed.

Information at hand indicates that reduction works are projected (possibly they are now in use) at York, Pa., and that crematories are projected at Long Branch, N. J., Charleroi, Pa., Columbia, S. C., Canton, O., Elgin, Ill., Greenville, Tex., Spokane, Wash., and Fresno, Cal. These places range from 36,848 to 5,930 in population.

Perhaps sufficient emphasis has not been placed upon the fact that nearly all the reduction plants are in large cities. It has already been stated that 15 of the 22 reduction works are in places of 100,000 and upwards. It may be added that of the 14 places of 200,000 population and over which employ improved means of garbage disposal 10 have reduction and only 4 cremation works. Also that only three of the reduction plants are in places of less than 40,000 population, namely, Vincennes, Ind., Belleville and Mount Vernon, Ill. Possibly, some mistake has been made in one or more of these three cases. In fact, the Mount Vernon report has been queried.

In conclusion, it is evident that providing improved means of garbage disposal affords a large opportunity for engineers and contractors, and is bound to become a most common, as it is already a most perplexing, municipal problem. The problem, however, is essentially engineering in character, and many of its perplexing features will rapidly disappear with a growing recognition of that fact.

LETTERS TO THE EDITOR.

Moving Load Shears in Trusses with Parallel Chords.

Sir: When I wrote the note published in your number of April 10, I never expected that anybody would think I was claiming the discovery of a formula long known by every bridge engineer and which was ancient ten years before Professor Johnson published his book.

The only point I wanted to make clear was that the maximum stress from moving loads in the web members of a truss is most easily derived from the ordinary shear in a girder of less span. This was easily to be inferred from the exact formula, but was not apparently inferred by Professor Johnson, as he did not consider the loading of Fig. 1 in my note, and I am not aware that the inference has been stated by anybody. Using Professor Johnson's notation, page 51, there seems to be no reason why the exact factor $\frac{(n-m)^2}{n-1}$ is replaced by the approximation $\frac{(n-m)\,(n-m+1)}{n}$ in several well-known text-books.

The actual difference between the stresses found by the two formulae is

$$\frac{(m-1)\,(n-m)}{n\,(n-1)} \times \text{half panel load}$$

and is maximum at center. But what is of real importance is the percentage of error, or ratio of the excess to the true value. It is $\frac{m-1}{n\,(n-m)}$ and increases when m increases, and when n diminishes. For instance, in a truss of five equal panels the error will be 20% in the first counter and 60% in the second one, which is not inconsiderable. Yours truly,

H. E. Vautelet,
Assistant to Chief Engineer, Canadian Pacific Ry.
Montreal, April 25, 1902.

Planetable and Transit Methods in Irrigation Canal Surveys.

Sir: As two articles have recently appeared in Engineering News on transit and planetable surveys,* it might interest some of your readers to learn of the methods adopted by the United States Geological Survey in the location of canal lines.

For several years past the hydrographic division of this bureau has undertaken the examination and survey of reservoir sites and canal lines for irrigation purposes in the arid West. The St. Mary River project, in Northern Montana, which contemplates storing the waters of this basin and then diverting them to the adjoining basin to the eastward—that of Milk River—is one that has been under recent investigation.

During 1901 the following field methods were adopted: The work consisted principally in locating a number of canal lines. The country is rolling and somewhat rough in places, but it is open and timber is scarce; in fact, at times a round-trip haul of 60 miles had to be made for wood for camp purposes.

The field party was made up of one chief, one assistant chief, one man acting as transit and levelman with two rodmen, one planetable man with two rodmen, one cook and one teamster—ten men in all. The duties of the chief of party consisted principally in deciding on the general location of the line, after thorough exploration of the country with aneroid, from 10 to 15 miles in advance of the instrument parties, had been made; the assistant chief was employed in triangulation, in keeping office work up to date, in making special topographic surveys and in stream gagings. The first field party was the level and transit party, made up of an instrument man and two rodmen. Their duties consisted in placing stakes by the level at varying distances from 300 to 400 ft. apart on the approximate center line of canal. After a day's work at this occupation, the next was spent by the same party in locating these stakes by transit and stadia. In the leveling work the same methods were pursued, and the same degree of accuracy was required as is customary with the regular leveling work of the topographic division of the Geological Survey; that is, the leveling lines had to close with an error in feet of not to exceed $0.5\sqrt{\text{distance in miles}}$. All distances were measured with stadia, using the ordinary Philadelphia rod. When such a reading was desired, the rodman would invert his rod; then the transitman would set one cross-hair on the upper end of the rod, which, numerically, was the bottom of the rod. The target was then placed so as to coincide with the other cross-hair. By this method distances could be obtained with a considerable degree of accuracy. The level party would generally average from four to six miles per day. As the next day was taken up in running over the same line with transit, the party actually progressed from two to three miles per day.

*March 13, p. 207; April 10, p. 296.

The transit notes were then plotted in the field office on a long roll of detail drawing paper on a scale of 400 ft. to 1 in. The plotting was done by chords of the angles instead of with a protractor or by the tangents of the angles, as it was considered that a greater degree of accuracy could thus be obtained. The transfer of the plotted points was made to planetable sheets by simply pricking through the points on the original sheet with a needle.

The second party consisted of one planetable man and two rodmen, one of the latter at times in rough country acting as station assistant in reducing the vertical angles with a slide rule. This party mapped the topography of the line with a planetable upon a scale of 400 ft. to 1 in. and with 5-ft. contours. From 300 to 500 ft. on each side of the center line of stakes was thus covered.

As it was known that a stretch of country above 100 miles in length would be covered by the end of the season, it was considered best to carry along with the work a system of triangulation for the control of the canal line; and as the work was within from five to ten miles of the Canadian boundary line, it was also necessary to know that the location was always within the United States territory. The sides of the triangles selected ranged from three to six miles in length, and the angles were measured with a Berger transit reading to 20 seconds, used also for the canal line survey, and was performed on the days when the levels were being run.

Special topographic surveys were made at certain points on the line, such as places where drops in grade of the canal will be necessary, and at crossings of deep ravines. The planetable sheets were inked in the field when the weather conditions were such that instrument work could not be carried on.

In this way 235 miles of canal line were located during the field season of 3½ months, or from the middle of July to the end of October. This included all days upon which work was not prosecuted, such as Sundays and stormy days. For instance, early in September nearly a week was lost on account of a snowstorm. Sixty-six miles of canal a month were thus located, or 2.2 miles per day.

The cost of the work, including the salary of the chief of party and of all assistants, their traveling expenses to the point of employment and all incidental expenses, was

TABLE VII.—GARBAGE REDUCTION AND CREMATION PLANTS IN PLACES OF 3,000 POPULATION AND UPWARDS, BY THE U. S. CENSUS OF 1900.

Boston, Mass.	560,892	Reduction.	Cleveland, O.	381,768	Reduction.
Lowell, Mass.	94,969	Cremation.	Columbus, O.	125,560	Reduction.
New Bedford, Mass.	62,442	Reduction.	Dayton, O.	85,333	Cremation.
Bridgeport, Conn.	70,996	Cremation.	East Liverpool, O.	16,485	Cremation.
Waterbury, Conn.	45,859	Cremation.	Findlay, O.	17,613	Cremation.
Buffalo, N. Y.	352,387	Reduction.	Glenville, O.	5,588	Cremation.
New York, N. Y.	3,437,202	Reduction[1]	Hamilton, O.	23,914	Cremation.
Syracuse, N. Y.	108,374	Reduction.	Mansfield, O.	17,640	Cremation.
Troy, N. Y.	60,651	Cremation.	Youngstown, O.	44,885	Cremation[2]
Utica, N. Y.	56,383	Reduction.	Anderson, Ind.	20,178	Cremation.
Yonkers, N. Y.	47,931	Cremation.	Elwood, Ind.	12,950	Cremation.
Atlantic City, N. J.	27,838	Cremation.	Evansville, Ind.	59,007	Cremation.
Camden, N. J.	75,935	Cremation.	Fort Wayne, Ind.	45,115	Cremation.
Paterson, N. Y.	105,171	Reduction.	Indianapolis, Ind.	169,164	Reduction.
Trenton, N. J.	73,307	Cremation.	Lafayette, Ind.	18,116	Cremation.
Allegheny, Pa.	129,896	Reduction.	Marion, Ind.	17,337	Cremation.
Allentown, Pa.	35,416	Cremation.	Muncie, Ind.	20,942	Cremation.
Bradford, Pa.	15,029	Cremation.	Richmond, Ind.	18,226	Cremation.
Butler, Pa.	10,853	Cremation.	South Bend, Ind.	35,999	Cremation.
Coudersport, Pa.	3,217	Cremation.	Terre Haute, Ind.	36,673	Cremation.
Hazelton, Pa.	14,230	Cremation.	Vincennes, Ind.	10,249	Reduction[3]
Jeannette, Pa.	5,862	Cremation.	Detroit, Mich.	285,704	Reduction.
Lancaster, Pa.	41,459	Cremation.	Grand Rapids, Mich.	87,565	Cremation.
McKeesport, Pa.	34,227	Cremation.	Belleville, Ill.	17,484	Reductn(?)
Oil City, Pa.	13,264	Cremation.	Chicago, Ill.	1,698,575	Cremation[4]
Philadelphia, Pa.	1,293,697	Reduction.	Evanston, Ill.	19,259	Cremation.
Pittsburg, Pa.	321,616	Reduction.	Joliet, Ill.	29,353	Cremation.
Reading, Pa.	78,961	Reduction.	Lincoln, Ill.	8,962	Cremation.
Scranton, Pa.	102,026	Cremation.	Mt. Vernon, Ill.	5,216	Reduction.
Wilmington, Del.	76,508	Cremation.	Milwaukee, Wis.	285,315	Cremation.
District of Columbia.	278,718	Reduction.	Des Moines, Ia.	62,139	Cremation.
Newport News, Va.	19,635	Cremation.	Oskaloosa, Ia.	9,212	Cremation.
Norfolk, Va.	46,624	Cremation.	Minneapolis, Minn.	202,718	Cremation.
Richmond, Va.	85,050	Cremation.	Topeka, Kan.	33,608	Cremation.
Benwood, W. Va.	4,511	Cremation.	Butte, Mont.	30,470	Cremation.
Fairmont, W. Va.	5,655	Cremation.	Helena, Mont.	10,770	Cremation.
Wheeling, W. Va.	38,878	Cremation.	St. Louis, Mo.	575,238	Reduction.
Charlotte, N. C.	18,091	Cremation.	Corsicana, Tex.	9,313	Cremation.
Greensboro, N. C.	10,035	Cremation.	Dallas, Tex.	42,638	Cremation.
Atlanta, Ga.	89,872	Cremation.	Gainesville, Tex.	7,874	Cremation.
Brunswick, Ga.	9,081	Cremation.	Houston, Tex.	44,633	Cremation.
Macon, Ga.	23,272	Cremation.	Taylor, Tex.	4,211	Cremation.

(Table VII.—Continued.)

Savannah, Ga.	54,244	Cremation.	Waco, Tex.	20,686	Cremation.
Jacksonville, Fla.	28,429	Cremation.	Portland, Ore.	90,426	Cremation.
Memphis, Tenn.	102,320	Cremation.	San Francisco, Cal.	342,782	Cremation.
Covington, Ky.	42,938	Cremation.	Santa Rosa, Cal.	6,673	Cremation.
Louisville, Ky.	204,731	Cremation.	Ogden, Utah.	16,313	Cremation.
Akron, O.	42,728	Reduction.	Salt Lake City, Utah.	53,531	Cremation.
Cincinnati, O.	325,902	Reduction.			

[1]Also several minor cremation plants in outlying districts.
[2]Garbage not collected at present.
[3]Plant reported burned in 1901.
[4]Small portion.

TABLE VIII.—PLACES REPORTING PART OR ALL OF THEIR GARBAGE BURNED

Ft. Fairfield, Me.;	Winston and	Ironwood, Mich.;	Brownsville, Tex.;
Lewiston, Me.;	Salem, N. C.;	Laurium, Mich.;	Bryan, Tex.;
Skowhegan, Me.;	Union, S. C.;	Negaunee, Mich.;	Cleburne, Tex.;
Concord, N. H.;	Milledgeville, Ga.;	Port Huron, Mich.;	Denton, Tex.;
Keene, N. H.;	Rome, Ga.;	Sault Ste. Marie, Mich.	Ennis, Tex.;
Montpelier, Vt.;	Apalachicola, Fla.;	South Haven, Mich.;	Galveston, Tex.;
Framingham, Mass.;	Ocala, Fla.;	Champaign, Ill.;	Greenville, Tex.;
Danbury, Conn.;	Pensacola, Fla.;	Decatur, Ill.;	Hillsboro, Tex.;
Winsted, Conn.;	St. Augustine, Fla.;	Galena, Ill.;	San Antonio, Tex.;
Hornellsville, N. Y.;	Tampa, Fla.;	Antigo, Wis.;	So. McAlister, Ind. Ter
Little Falls N. Y.;	Anniston, Ala.;	Merrill, Wis.;	Elreno, Okla.;
Mt. Vernon N. Y.;	Tuscaloosa, Ala.;	Centerville, Ia.;	Perry, Okla.;
Salamanca, N. Y.;	Lake Charles, La.;	Chariton, Ia.;	Aspen, Colo.;
Wellsville, N. Y.;	Plaquemine, La.;	Fort Dodge, Ia.;	Boulder, Colo.;
Elliott, Pa.;	Union City, Tenn.;	Keokuk, Ia.;	Leadville, Colo.;
Franklin, Pa.;	Dennison, O.;	Muscatine, Ia.;	Victor, Colo.;
Johnsonburg, Pa.;	Fostoria, O.;	Crookston, Minn.;	Aberdeen, Wash.;
Punxsutawney, Pa.;	Kenton, O.;	Two Harbors, Minn.;	Eureka, Cal.;
Ridgeway, Pa.;	Salem, O.;	Hutchinson, Kan.;	Grass Valley, Cal.;
St. Clair, Pa.;	Alexandria, Ind.;	Hastings, Neb.;	Los Angeles, Cal.;
St. Mary, Pa.;	Dunkirk, Ind.;	Aberdeen, S. Dak.;	Napa, Cal.;
Stroudsburg, Pa.;	Fairmont, Ind.;	Deadwood, S. Dak.;	Nevada City, Cal.;
Tyrone, Pa.;	Noblesville, Ind.;	Mitchell, S. Dak.;	San Diego, Cal.;
New Castle, Del.;	Alpena, Mich.;	Sioux Falls, S. Dak.;	Santa Ana, Cal.;
Petersburg, Va.;	Cadillac, Mich.;	Fargo, N. Dak.;	Prescott, Ariz.;
Staunton, Va.;	Hancock, Mich.;	Abilene, Tex.;	Boise, Idaho.
Edenton, N. C.;	Houghton, Mich.;	Beaumont, Tex.;	
Raleigh, N. C.;			

at the rate of $22 per mile. The cook, teamster and rodman received from $35 to $50 per month; planetable man and transitman received $60 and $100 per month, respectively, and assistant chief and chief of party $125 and $150 per month, respectively. The rodmen were picked up in the vicinity and had had no previous training.

Mr. McCullough, in his article in Engineering News of April 10, criticises large parties. The present writer thinks, on the other hand, that a party should not be too cramped, but should not contain more men than can constantly be used on the work. It can readily be seen that the work would be carried forward more rapidly with a large party than with a small one, if every man were kept employed. For instance, a piece of work—say a stretch of railroad—can be built in a shorter time with a force of 600 men than with 100 men. The rate of Mr. McCullough's survey was less than a mile a day, presumably all working days; on the St. Mary survey the rate was 2.2 miles per day, including the time that was lost. In the same article, using the rate of pay of the different assistants as there given, the survey was found to cost $27 per mile, as against $22 per mile for the St. Mary survey.

After returning to the office in Washington, a paper location of the canal line was made and cross-sections computed with a sufficient degree of accuracy, considering that no test borings along the line were made upon which to base preliminary estimates of cost.

Cyrus E. Babb, Assoc. M. Am. Soc. C. E.

Washington, D. C., April 18, 1902.

Notes and Queries.

P. O., Santa Clara, Cuba, writes us that the great Bethlehem steam hammer whose demolition was noted in our issue of April 10 is probably not the largest in the world. He says:

I remember having seen a full-size model of a 150-ton steam hammer exhibited on the grounds of the Antwerp International Exposition in 1885 or 1886—I do not quite recollect the exact date—by the Cockerill Co., of Seraing, Belgium. A large sign on the model informed the visitors that the original 150-ton hammer had been furnished by said builders to the well-known Terni Works, of Terni, Italy, where it is still likely to be in operation.

Since the above was in type our attention is also called to a published statement that the new forge shop of the Fore River Ship & Engine Building Co., at Quincy, Mass., contains a 250-ton steam hammer. It is possible, however, that this figure refers to the weight of the whole machine and not the reciprocating parts alone, as in the case of the Bethlehem hammer.

"Subscriber," Rochester, N. Y., writes:

Please inform me through your valuable paper what are the different parts of the best American gypsum and what percentage of each. Is pure gypsum a valuable article?

In answer to the above, we print the following extract from a paper on "The Classification of the Crystalline Cements," by Mr. Edwin C. Eckel, Assoc. Am. Soc. C. E., of the New York State Museum, Albany, N. Y. The paper was published in the "American Geologist" for March, and has been reprinted separately by its author:

HYDRATE CEMENTS.

The raw material on which all the commercial cements of this class are based is gypsum. By its partial dehydration is produced plaster-of-paris, by far the most important member of the group. By the addition of relatively small amounts of certain other materials and by slightly varying the processes of manufacture, the time of setting, hardness and other properties of the plaster can be changed sufficiently to warrant separate naming of the resulting products, some of which are of considerable commercial importance for special uses.

PLASTER-OF-PARIS.—Gypsum is a hydrous sulphate of calcium ($CaSO_4$, $2H_2O$), whose composition, when pure, corresponds to sulphate of lime 79.1%, water 20.9%. As mined, it is usually far from pure, carrying at times as high as 25%, or even more, of impurities, chiefly silica, alumina, oxide of iron and calcium carbonate. Certain of these foreign ingredients seem to exercise an appreciable effect upon the rate of set of the resulting plaster. In addition to these variations from natural causes, "accelerators" and "retarders" are frequently employed.

Upon heating to about 120° to 130° C., gypsum loses three-fourths of its water. Plaster-of-paris, the result of this incomplete dehydration, is a definite hydrous calcium sulphate with the formula $2CaSO_4$, H_2O, corresponding to the composition sulphate of lime 93.8%, water 6.2%. (Complete dehydration of gypsum, which would occur at about 170° C., would result in the formation of an anhydrous lime sulphate corresponding to the mineral anhydrite. This completely anhydrous sulphate re-hydrates very slowly, and is consequently of no commercial importance.)

Upon the addition of water, plaster-of-paris rapidly re-hydrates and "sets," reassuming the composition of gypsum. The rate of set of plaster is regulated by the addition of non-crystalline materials (blood, glue, starch, etc.), which serve to retard the set; or of alum or borax, which accelerate it.

KEENE'S PARIAN, and other hard-finishing cements are made by adding to plaster-of-paris a dilute solution of borax or alum, and, after drying, reheating at a low red heat.

AN ELECTRIC PICTURE TELEGRAPH.

An improved form of apparatus for electrically transmitting pictures over a wire has been patented during the past year, and is now being introduced by a Cleveland company. Samples of the work produced by the machine seem to promise it a considerable range of usefulness.

The principle of the new picture telegraph, or "electrograph," as it is called, is the same as has been previously employed for the purpose. At the two ends of the line are pencils moving in synchronism, respectively, over the picture to be transmitted, and the blank receiving sheet; by traversing these surfaces in a great number of parallel lines closely set together the pencils cover

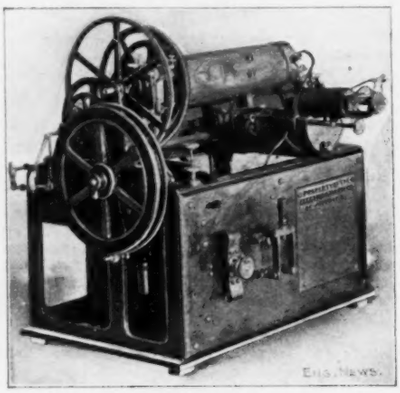


Fig. 1. Electrograph Instrument for Picture-Telegraphy.

practically the whole surface of the picture. The arrangement of the terminal instruments is such that the receiving pencil reproduces the dark and light portions of the line of motion of the transmitting pencil, so that the composite arrangement of dark lines or dots gives a picture-effect more or less closely similar to the original. In the present instrument the light and shade is distributed on the half-tone principle, so that the transmitted picture may give the effect of all degrees of light and shade; the picture, moreover, appears at the receiving end in black, so that it is at once available for reproduction by the processes of photographic etching. As another important matter, the speed of transmission attained is very great compared to past results, so that the cost of the resulting pictures is brought, it is claimed, to a commercial point.

A view of the terminal apparatus is given in Fig. 1. The same instrument may be used for transmitting or receiving, with a slight difference in its mode of employment. In either case the picture or copypaper is wound around a cylinder, seen in the illustration at the top of the instrument, which is rotated at a uniform speed. A special arrangement is provided for synchronizing the cylinders at the two ends of the line. If the cylinders are out of synchronism when a certain point of the revolution is reached, the one which is in the lead is retarded or stopped until the other cylinder catches up; any momentary difference in rotative speed of the two cylinders is in this way corrected once in each revolution, and as a result the cylinders move in perfect synchronism, i. e., are at any instant at corresponding points of the revolution. The electric impulse used in this synchronizing device travels over the same wire used for the picture transmission, the synchronizing point being chosen at the lap of the paper, outside of the picture itself.

Adjacent to the rotating cylinder of the instrument is mounted a pen-carriage, which bears interchangeably a metal stylus or an inking-pen. This carriage is moved at uniform speed along the face of the cylinder, so that the marking point traces a fine-pitch helical line on the latter. This is equivalent to tracing parallel lines across the picture, as referred to above. The further details and the working of the apparatus will be apparent from the following description of the steps in the process of sending a picture.

The picture to be telegraphed by the "electrograph" method is first worked into a half-tone plate; this is a copper plate having on its surface fine raised dots uniformly spaced, but varying in heaviness (size) with the depth of shading at the corresponding point in the picture (as can be seen in Fig. 1, which is a half-tone made from a photograph of the instrument). For the purposes of the electrograph it is desirable that the raised metallic dots of the plate be spaced [illegible] apart than those of the ordinary half-[illegible] for this reason a zinc enlargement is made [illegible] the half-tone plate, by photographic etching [illegible] which produces a similar plate with the dots [illegible] proportionately larger and of wider spacing. The [illegible] plate is then coated with wax to fill the depressi[illegible] and rubbed smooth, presenting a surface of alte[illegible]ting metallic and insulating spaces, produced [illegible] the metallic dots and the wax in the depress[illegible].

The finished plate is wound around the [illegible]ns-mitting cylinder; when the stylus travels [illegible] its surface, the electric line circuit will be [illegible]ed while the stylus is over one of the metalli[illegible]ts, and will be interrupted while the stylus [illegible]es over the intervening wax surface. At the receiving end the mechanism is arranged so that the pen is pressed against the paper and makes [illegible]nk mark, while the electric impulse passes over the wire, and is raised clear of the paper when no impulse passes. On account of the weak line currents and the rapid alternation of the impulses the proper receiving mechanism to operate the pen in this way was a point of much difficulty.

A very ingenious arrangement was finally devised, constituting one of the chief points of interest about the instrument. Two sets of magnet coils arranged in opposition are placed so that their cores act upon the pen, one operating to press it against the paper, the other to draw it back. Of these the former set of coils has a core of very soft iron, the other cores of slightly harder iron. When the electric impulse reaches the coils, the recording coils will energize their cores instantaneously, while the others, having to act against a greater magnetic lag in the harder cores, will remain practically inert. The pen is, therefore, pressed against the paper and makes a mark of ink on its surface. When the electric impulse ceases, the cores of the recording coils lose most of their magnetism immediately, while the greater retentive power of the harder cores leaves their magnetism (which has meanwhile "built up") at almost full value; thus the pen is drawn back with about full line-current force. A spring to draw the pen from the paper is therefore not necessary, and the receiving pen follows the most rapid alternation of impulses with practically no lag. In consequence, a speed of rotation

Fig. 2. Picture of Senator J. W. Palmer, of Detroit, Mich., Transmitted Over 800 Miles by Electrograph, ½ Size of Copy, as Transmitted and Received by Instrument.

of the cylinders may be successfully employed that makes the time required for transmission of a complete picture, very small, and correspondingly brings down the cost of the transmission to a low figure.

For rotating the cylinders, each instrument has mounted within it a small electric motor, run

with local current, usually at 110 volts' pressure, the same motor also operating the pen-traveling mechanism. The speed of the pen-travel can be varied by gearing, so that the spacing of the lines traced by the pen can be adjusted to suit the work in hand. It is to be noted that the arrangement of all parts of the mechanism is such that the operation of transmitting the picture may be interrupted at any moment and the line used for ordinary Morse telegraphy; when the "electrographs" are again thrown into circuit they at once adjust automatically to start at the point where they stopped (or the next synchronizing point).

A picture telegraphed by the electrograph method is reproduced in Fig. 2, reduced to about one-third the size of the copy received. The fine parallel lines that compose the picture, and the way in which they simulate the diagonal screen effect of the original half-tone plate will be observed in the illustration.

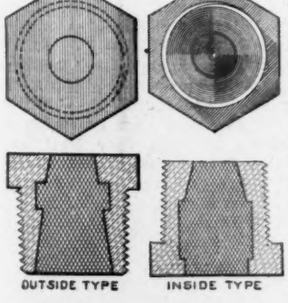
It is expected that the electrograph will soon be in wide use in newspaper work, this evidently being the field to which is is mainly adapted. The speed of transmission is well within the limits required to make it a completely practical method for such use. The picture reproduced in Fig. 2 was sent over a distance of 800 miles, and took about ten minutes for transmission.

The electrograph apparatus is the joint invention of Messrs. Thos. Mills and H. R. Palmer, of Cleveland, O. The invention is being exploited by "The Electrograph Company of America," a corporation composed of Cleveland capitalists; its president is Mr. F. B. Squire, Cleveland, O., and Mr. H. R. Palmer, one of the inventors, is Consulting Engineer for the company.

FUSIBLE PLUGS FOR STEAM BOILERS.

Many of our readers will remember the disastrous explosion which occurred on the steamboat "City of Trenton," on the Delaware River, near Philadelphia, last fall, in which many lives were lost and which was found to have been caused, according to the best evidence obtainable, by low water in the boilers, which were of a type in which the normal depth of water over the furnaces is so small that a very brief interruption of the feed suffices to lay the crown sheet bare. In the evidence at the inquest which followed the disaster, it transpired that there was a good deal of doubt as to the composition of the fusible plugs which were in the crown sheet, and which should have melted and allowed the steam to blow out and give warning of the condition of the boiler long before the danger point was reached.

The U. S. Treasury regulations require the use of fusible plugs of bronze, filled only with pure Banca tin. The melting point of tin is 455° F., and the metal is not altered in any way by long exposure to heat, whereas some of the fusible metal alloys are believed to change their melting point in the course of time. In addition, the Government requires that all such plugs shall have stamped upon them the name of manufacturer, and that an affidavit certifying to the composition of the metal used for the filling shall be filed with the Inspector. The accompanying cuts show fusible plugs conforming to the Government requirements, which have been put on the market by the Lunkenheimer Co., of Cincinnati, O. It will be seen by the sectional views that the cross-section of the fusible metal in these plugs is largest on the water side, thus lessening the chance that scale or mud over the plug will bridge over the opening left by the metal when it is melted out. The only criticism we can suggest on the design would be that it would be better to make the plugs project a little farther on the water side, and give a little better chance for them to reach above the coating of scale and mud, etc., which forms on the heating surface, and which is probably the most common cause of the failure of a fusible plug to give the warning it is meant to give.



PRIZES FOR AN ALCOHOL-MOTOR DRAFT-WAGON are offered by the German Ministers of War and Agriculture. The specifications call for a machine weighing, equipped, supplied and manned, not over 15,750 lbs., with not more than 11,023 lbs. on one axle. It must make three miles per hour over grades of 1 in 10, or 43.5 miles per day, on good roads; and haul 31,500 lbs. under these conditions. It must carry enough spirits, oil or other materials sufficient for a run of two days without replenishing. When running without a trailer, the wagon must mount grades of 1 in 5, and it must ford streams with water not exceeding 16 ins. in depth. The height of fixed portions must not exceed 8 ft. 3 ins. above road level, the width to be not more than 7 ft., and the length 19 ft. 9 ins. The motor must be able to use crude alcohol, or alcohol mixed with benzine or other product of petroleum, without injury to the working parts. The prizes offered are 10,000, 5,000 and 2,000 marks, or $2,380, $1,190 and $476 respectively, and all machines must be entered for a 3-weeks' trial before February 1, 1903; complete working drawings and details and originals of patents to accompany the machine itself.

TRACK RAISING IN NEWARK, N. J., is to cost the Delaware, Lackawanna & Western R. R. Co. the sum of $3,000,000. Work has been commenced and it will require about three years to complete the improvement. The Pennsylvania and New Jersey Central companies will complete their similar work in a few months. The work contemplated by the D., L. & W. company covers a length of about one mile.

A CONCRETE AND EXPANDED-METAL SEWER with a daily capacity of 20,000,000 gallons has been built near Syracuse, N. Y., by the Solvay Process Co. to remove the water from its cooling plant. The sewer is horseshoe shaped, about 5 × 5 ft., and has a length of 2,000 ft. It is 9 ins. thick at the lowest part of the invert. Its sides are also 9 ins. thick and the ring diminishes to about 6 ins. at the crown. There is one layer of expanded metal, 3-in. mesh, of No. 10 steel, embedded in and extending completely around the sewer. The sewer was designed by Mr. Geo. Root, Civil Engineer of the company, and constructed under the general supervision of Mr. E. M. Trump, Chief Engineer of the company.

BACTERIAL STUDIES of water of public swimming baths indicate that each bather contributes from 4,000,000,000 to 6,000,000,000 bacteria to the swimming pool at each bath, but that "the swallowing of water of the type analyzed was quite innocuous." The studies were the subject of a recent paper read before the Liverpool Medical Institution by Dr. R. G. Glynn. Most of the samples examined were from baths filled each morning with fresh and nearly sterile water. The average of five counts of cultures from samples taken from a plunge bath at 9 p. m., during June and July, gave 4,676 bacteria per cu. cm., the average number of bathers having been 292. From these figures the contributions per bather, given above, were calculated. The kinds of bacteria found are thus stated in an abstract of Dr. Glynn's paper, which appeared in the "Medical Record" of April 26:

> . . . . . streptococci were never found and staphylococcus aureus and citreus very rarely; staphylococcus albus was abundant in three varieties—pyogenes albus, epidermidus albus and cereus albus. At the end of the day bacillus coli was present in the bath to the number of eight per liter for each bather in first-class baths and 48 for each bather in the second class.

The very sensible suggestion is made that public bathhouses should be well ventilated and that their temperature should be properly regulated.

CAST-STONE CONCRETE construction was described in our columns some time ago, and a special patented cast-stone or "litholite" is now being introduced for buildings, both in walls and in such decorative work as lintels, cornices, interior and exterior staircases, balconies, etc. Stone crushed to a granular condition is used, mixed with Portland cement, and sometimes with sand in addition, the wet concrete being cast in molds as blocks or decorative pieces, and no ramming being required. The blocks may be either solid or hollow, as in terra-cotta work. The material has been used in a number of buildings, including the lower stories of the remodeled Morse Building in New York. The system has been patented by Mr. C. W. Stevens, President of the Stevens Cast-Stone Construction Co., Metropolitan Building, 1 Madison Ave., New York City.

THE OLDEST DATED STONE BUILDING, says Prof. W. M. Flinders Petrie, in a recent lecture before the Royal Institute of British Architects, is the pit chamber of King Khasekhemui, of the Second Dynasty of Egyptian Kings, about 4350 B. C. This chamber is 17 × 10 ft. in dimensions and 6 ft. deep, and is lined by limestone blocks laid in fairly regular courses, averaging 1 ft. thick. Most of the faces of these stones are hammer-dressed and adzed over, probably by a flint tool, as is shown by the nature of the breaks on the faces and edges of the courses. The joints were laid in mortar. The same king also worked in granite, and slabs of pink and gray granite were used for paving the tomb of King Den, about 4700 B. C. A house built of hewn granite is credited to King Neter-Khet, of the Third Dynasty, about 4200 B. C.

THE FAMOUS LONDON BRIDGE, over the Thames, is to be widened at a cost of $475,000. The present structure was built from plans by John Rennie and opened to traffic in 1831; including approaches, it cost $7,291,556.

BOOK REVIEWS.

THE COPPER HAND-BOOK.—A Manual of the Copper Industry of the United States and foreign countries. Vol. II., 1902. Compiled and Published by Horace J. Stevens. Houghton, Mich. Paper; 5¾ × 8¾ ins.; pp. 416. $2 in buckram; $3 in full morocco.

The second edition of this compendium of the copper industries of the world brings the statistics and history up to date. It covers the history, chemistry, mineralogy and metallurgy of copper; the known deposits of copper in the world, and a glossary of mining terms in common use. It lists and describes about 700 copper mines.

ELECTROMAGNETS.—Their Design and Construction. Being a revision of No. 64 of Van Nostrand's Science Series. By A. N. Mansfield, S. B. Boards; 3½ × 6 ins.; pp. 155; 5 tables; 36 illustrations. New York: D. Van Nostrand Co. Price, 50 cts.

This little volume is intended to replace a previous volume of this series dealing with the same subject. The many changes required to bring the old work up to date induced the publishers to make it an entirely new issue instead of a mere revision. The book deals in short and practical manner with the history of the subject, general considerations and phenomena of magnetic circuits, and properties of magnets; then it takes up questions of design and construction, which are concisely yet thoroughly treated. A rather brief concluding chapter treats of electromagnets for alternating currents. Throughout the presentation of the subject is practical, yet including all the necessary formulas for the calculation and construction of electromagnets. The book should prove a good text-book and a convenient reference hand-book on the subject.

A B C OF THE TELEPHONE.—A Practical and Useful Treatise for Students and Workers in Telephony. By J. E. Homans. Cloth; 5 × 7¼ ins.; pp. 335; 208 illustrations. T. Audel & Co., New York. Price, $1.00.

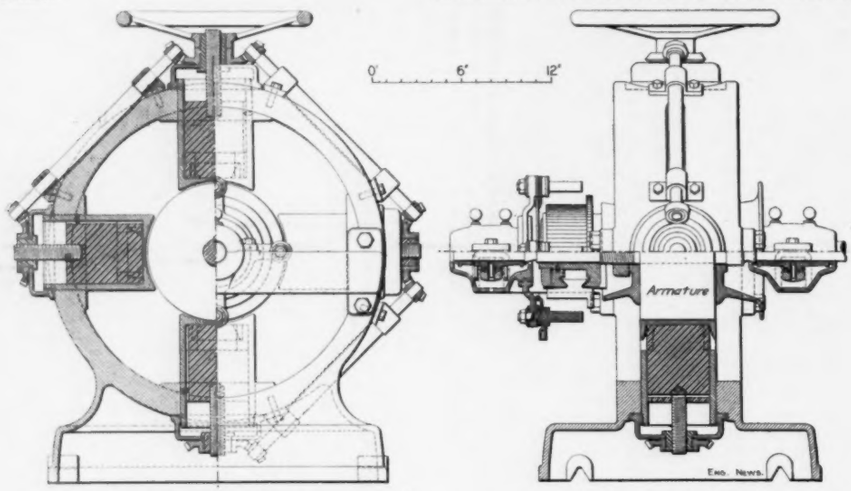
The preface states that the book is "an elementary and general treatise," designed to give a plain and intelligible review of the subject without advanced and complicated discussion. The book appears to begin the subject on a very elementary basis, yet progresses to a description of all modern devices and accessories of a telephone system. The treatment impresses one as being excessively and unnecessary elementary in its first portion; in the last half, without introducing any "advanced and technical discussion," it seems to be greatly lacking in clearness, for this very reason, perhaps, and also because of the great amount of matter which is brought in. The illustrations suffer from this same complaint; there are too many of them and they are very poor, being mostly reproductions from manufacturers' wood cuts. We imagine that if the larger share of the cuts had been omitted, and the text much reduced in bulk and treated on a uniformly simple basis, the book would have come considerably nearer its title-page description of "practical and useful treatise for students and worker in telephony."

AMERICAN STANDARD SPECIFICATIONS FOR STEEL.—Being the revised text of the American Standard Specifications for Steel as adopted by the American Section of the International Association for Testing Materials, together with an explanatory review of its main clauses by the author. By Albert Ladd Colby, Member of Committee No. 1 of the American Section of the International Association for Testing Materials. Cloth; 5 × 7 ins.; pp. 103. Published by Albert Ladd Colby, South Bethlehem, Pa. Price, $1.10.

The scope of this work is well indicated in the title. It represents the results of a great amount of labor on the part of the committee that drew up the specifications, and in the explanatory review by the author, a member of the committee, it gives some insight into the method and extent of their work. The contents of the book comprise a brief historical introduction, a general review of requirements specified in the specifications, a separate review of each of the sections of the specifications, and finally the revised text of these latter themselves, divided into nine separate sections, each forming a complete specification for its class, as follows: (1) Steel Castings, (2) Steel Axles, (3) Steel Forgings, (4) Steel Tires, (5) Steel Rails, (6) Steel Splice Bars, (7) Structural Steel for Buildings, (8) Structural Steel for Bridges and Ships, (9) Open-Hearth Boiler Plate and Rivet Steel.

These specifications appear to be an excellent compilation and elaboration of modern American practice. As such they are proposed as standards to be generally followed in the making and buying of steel in this country. The value of any authoritative attempt in this direction must be considerable, very much more so when such careful and conscientious labor has been bestowed upon its pre-

paration as is evinced by this set of specifications. It is to be sincerely hoped that engineers and manufacturers as well as users of steel will aid this attempt to secure uniformity, and in consequence economy and excellence, by adopting this standard as far as possible; and, it may further be hoped, and expected, that all possible examination and criticism will at once be brought to bear on these specifications, in order that they may, without delay, be amended and improved wherever this may be found necessary.



Sectional Side Elevation. Sectional End Elevation.

FIG. 1. SECTIONS AND ELEVATIONS OF 6-HP. VARIABLE SPEED MOTOR WITH VARIABLE RELUCTANCE.
Stow Mfg. Co., Binghamton, N. Y., Builders.

The points of interest to be noted in the specifications are many, too many in fact to be referred to here. It may be briefly noted, however, that one of the matters which the committee appeared to have constantly in view was to keep the number of governing specifications down to a minimum, eliminating all unnecessary, redundant, or conflicting requirements. Thus, the method of manufacture may be specified, but details of process or nature of raw material shall not be specified. Tensile strength and limiting phosphorus are specified in all cases, sulphur in most cases, manganese and silicon in some cases, but carbon is not specified (except in one or two cases) since when the preceding, and process of manufacture are defined, it is unnecessary, and often unfair, to specify the limiting amount of carbon. In connection with this elimination of unnecessary requirements, which are far too frequent in the many different sets of specifications under which steel is bought, a further important feature of these specifications may be noted. This is the fact that the specifications are framed to be fair to both maker and user of the steel, consistent with standard excellence and suitability for its purpose. Any one familiar with current specifications will recognize this as a most valuable feature. Only too often are the requirements of specifications either lax and insufficient or so severe as to be unjust or even impossible of fulfilment; in some cases, in fact, these two errors coexist, and the specification then, instead of being a protecting contract clause, becomes worse than a dead letter, and give rise to disputes instead of preventing them.

A NOVEL VARIABLE SPEED ELECTRIC MOTOR.

We illustrate herewith an interesting novelty in electric motors—a direct-current motor whose speed may be varied at will over a wide range without the use of controllers or other auxiliary devices and without appreciable variation in efficiency. This result is reached by surprisingly simple means, as will be evident from the following description of the machine:

The motor is shunt-wound, and is quite similar to any other machine of that type. The field magnets, however, are hollow, and within them are closely-fitting iron plungers, which, by means of gearing, may be moved toward or from the armature. Any movement of these plungers has the effect of varying the reluctance of the magnetic circuit, and with constant M. M. F. (on constant-potential circuit) the magnetic flux evidently changes correspondingly.

As will be noted, this is exactly what is accomplished in the ordinary method of regulating the speed of shunt-wound motors by the use of a variable resistance in series with the field. As the field is weakened, the motor speeds up so as to maintain the counter E. M. F. of the armature at approximately constant value. Similarly, when the field strength is increased, increased counter E. M. F. cuts down the armature current and the speed falls until the balance is restored. However, an important difference must be noted between the action of the ordinary field-regulated shunt motor and the present machine. In the former the field strength is increased or decreased uniformly over the entire pole-face, and thus the commutating conditions, which depend on the field strength near the edges of the pole pieces, differ under different speed conditions. In the present, which we may call "variable-reluctance" motor, on the contrary, the field strength around the edges of the pole faces remains practically constant, and the change in flux is concentrated over the central portions of the pole faces. In this way the conditions of commutation remain practically constant and sparkless commutation is secured throughout the full speed range.

The detailed construction of the machine is shown by the accompanying cut, Fig. 1. The figure shows sectional elevations of a four-pole motor of about 6 HP. capacity. A general view of the same machine is shown in Fig. 2. Referring to the sections, it will be seen that the frame of the fields supports four tubular inwardly-projecting field magnets, with closed pole faces at their inner ends and open at the outer ends. A soft-steel plunger is arranged to slide in the bore of each field magnet, and is moved inward or outward by a fixed screw passing through an internally threaded bevel gear. This gear wheel, as shown, rotates in a bonnet mounted on the frame in the axis of the magnet, and the four gears are all interconnected by short shafts bearing bevel pinions which mesh with the gears. The topmost gear is fitted with a hand wheel, and by turning this wheel all four gears rotate in unison and the four plungers in the field magnets are withdrawn or pushed in by equal amounts. Thus a complete magnetic balance of the armature is obtained at all times.

Fig. 2. General View of 6-HP. Stow Variable Speed Motor.

The remaining essential features of the motor are exactly similar to those of any other shunt-wound motor. The construction shown is open at the ends, but the motor is also built with enclosing end plates which carry the armature shaft in bearings at their center.

The builders of the motor, the Stow Mfg. Co., of Binghamton, N. Y., have sent us the following additional remarks:

The new type of multispeed motor has an operative speed range from normal or minimum speed to from 100 to 150% above minimum, the percentage of speed variation increasing with the size of the machine. The 6-HP. motor shown in the cut is designed for a minimum speed of 700 r. p. m., with a maximum of 1,500 r. p. m., and thus permits of a total speed variation of 115% of the normal. At any speed within these limits the machine develops its full rated power, with an efficiency of only 2% less at maximum than at minimum speed. (Its efficiency is 82% at minimum speed, 80% at maximum.)

To those familiar with the action of field regulated shunt motors of ordinary type a variation in speed of 115% by a corresponding variation of the magnetic flux would seem impossible of realization on account of the difficulty of securing sparkless commutation when the field strength of the motor is so abnormally reduced. In the construction of the present multispeed motor, however, the design of the pole piece and plunger is such that as the volume of effective magnetism is diminished by the outward movement of the plunger, the remaining magnetic flux is forced more and more in the direction of the pole-tips, thus furnishing a magnetic fringe at all times of sufficient intensity to insure sparkless commutation. In regard to the fineness of speed adjustment, it is evident from the construction of the machine that there is no speed between maximum and minimum which cannot be obtained by an appropriate adjustment of the hand wheel. The efficiency of these machines is in every case fully up to the standard of first-class modern practice. It should further be understood that while the motor carries its full load, sparklessly, at any imaginable speed within its range at practically maximum efficiency, it will also carry any lesser load with a consumption of power corresponding with the actual work done. The self-regulation of the machine is as close as, and in some cases closer than, the regulation of motors of common form, on account of the ample size of the armature conductors. The temperatures of the various parts of the machine, for open and enclosed types, come well within the heat limits accepted as standard practice.

The design of the pole-pieces and the selection of gearing is such that no great effort is required at the hand wheel in order to move the plungers against the pull of the magnetic field.

The machine shown in the accompanying illustration (Fig. 2) is being built in sizes from 5 HP. to 25 HP. For sizes above 25 HP. automatic means can be furnished for varying the speed.

A FOUNDATION FAILURE AND ITS RECONSTRUCTION.

There has just been completed in an Eastern city the reconstruction of a building foundation which failed some months ago. The work was accomplished under somewhat unusual difficulties, but is also of interest because of the other features of the case as a whole. The facts in the matter as given below were obtained from various persons connected with the work and are probably closely correct, at least in the main outlines; the names of the interested parties and the location of the building are withheld on account of an impending lawsuit.

During the year 1901 an eight-story building was erected on a plot of ground about 30 ft. by 180 ft., running north and south. The building had cast-iron columns, steel floor beams, brick curtain walls above the first floor level, and plaster composition floor arches. The columns footed on cast-iron bases at the street level, and these rested on a brick wall extending to the cellar level; this bearing wall in turn rested on a pile foundation. Though in the vicinity rock was found close to the surface there existed at the site of the building in question something in the nature of a pocket, so that the surface of bedrock was something over 20 ft. below the level of the cellar floor. The material overlying the rock was a clayey and sandy soil, but in its upper part there was a considerable amount of a peaty, elastic material, which was ordinarily filled with water.

The building was put up by a speculative builder, on a loan, and before it was entirely completed he failed, and the control of the building passed to his creditors. Plans for the building had been prepared by an architect, but they were merely general plans, such as are furnished for estimate and contract purposes; the architect had no further connection with the building, either in furnishing working plans or in superintending the construction. The building was put up in a manner which, it is said, fully bears out what might be expected to result from such a condition of affairs. To this fact may be attributed the nature of the foundations constructed for the cellar walls, which carried the weight of the building.

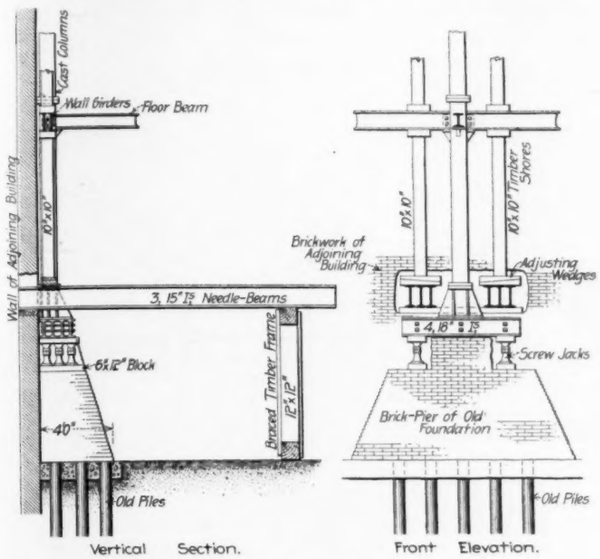


Fig. 1. Method of Supporting and Raising Eight-Story Wall.

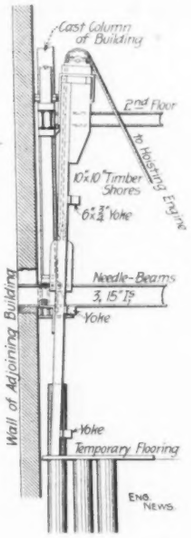


Fig. 2. Piledriving Rig for Driving Foundation Piles for Settled Wall.

The bearing wall, 2 ft. thick, was run down vertically for some distance and then stepped out to 4 ft. wide; piles were driven only under the portions of the wall which supported the columns; it is stated that of these piles some were not over 5 ins. diameter at the butt, and that most of the piles in diameter and length were entirely below the requirements of even indifferent practice.

When the building had been practically completed as regards framework, walls and floors, work was commenced on the foundations of a building adjoining this one on the west side for the north half of its length. Those columns of the new building which immediately adjoined the west wall of the completed building were founded on concrete-filled caissons carried to rock. In putting down the caissons, pumps were used to keep them clear of water. Even before the sinking of these caissons had been completed, it was observed that the eight-story brick wall next the work had settled, and that the wall in consequence leaned toward the west a maximum of about 8½ ins. The contractor for the foundation at once put up inclined timber shores resting against the wall at about the third story level; the shores were wedged up as tight as possible, but did not restore the wall. It was afterward found that they had forced inward the framework of the building at the third story level so that the whole building was buckled at that point. The upper part of the building was as far as ever from its original position, and the horizontal distance from inside of buckle to extreme overhang was as much as 15 ins. The settling and consequent leaning of the wall, and the buckling incident upon wedging up the shores, cracked through the stonework of the north front of the building in a number of places at and below the third story level. The damage was particularly noticeable in the false lintel of stone over the first story, which cracked and separated so as to indicate a total settling of the west wall of about 4 ins.

The damaged building was at once examined, and it was found that there was no immediate danger of further movement. The trustees then engaged a first-class firm of architects to plan for the necessary reconstruction. As it was apprehended that the ironwork would be found considerably damaged, it was at first thought best to take down all walls and floors in the affected portion of the building and then repair the framework as might be found necessary. The brickwork, etc., could then have been replaced in proper workmanlike manner to make a substantial job. Certain legal considerations, however, rendered it desirable to settle upon a plan of reconstruction that would involve only the most necessary expenditures, and in consequence a simplified scheme of work was tentatively adopted. The work was taken in hand under contract by an experienced firm of building contractors.

In preparation for the foundation work, the brickwork of the west wall was taken down for the full eight stories along the portion that had settled. As an old house three stories in height adjoined the building on the east, the east wall was also taken down in the upper five stories, to guard against possible accident. The brick and stone in the north front were also taken out in the full height of the building, properly marked and stored on the upper floors. The floors themselves it was decided to leave untouched, as the material would be practically valueless when removed.

The steelwork was now jacked up at the level of the first story and supported on needle-beams. The arrangement for this is shown in Fig. 1. Pairs of needle-beams, each consisting of three 15-in. I-beams, were placed at the sides of the columns, running transverse to the building as shown. At their inner ends they were supported on a timber frame resting on the ground, at their outer ends on the brick wall of the adjoining (west) building. Vertical 10 × 10-in. timbers were then placed on these needles to support the steel framework, and these timbers were wedged up to take the load off the column bases. Under these bases the brickwork was taken out and four 18-in. I-beams, 8 ft. long, were placed under the bases and supported at each end on three jacks; the jacks were supported on the brickwork of the existing foundation. By means of these jacks under each column, the framework of the whole wall was gradually raised to its original position, the vertical 10 × 10-in. timbers being kept wedged up as the wall raised. It was noted, while this work was going on, that on several occasions the framework seemed to raise of its own accord by a small jump. One such motion of ¾-in. and several of about ½-in. were observed; the former movement, in fact, took place while the brickwork of the west wall was being removed, and before any jacking was done. These motions were attributed in part to the elasticity of the peaty subsoil already referred to, which by this time was again saturated with water, and partly to the elasticity of the frame of the building itself, in connection with the reduction of the load by removing the brickwork and wedging the load off the foundation.

In this way the framework was finally restored to its original level; a slight residual leaning of the upper portion remained and this was left uncorrected. The whole load was then wedged off the jacks and transferred to the needle-beams mentioned above. The foundation brickwork could now be removed and the piling exposed. It was decided to leave in place the original piling, and to drive additional piles of good size down to rock, as close together as possible, over as much of the foundation as could be reached (no new piles could be driven directly under the columns or very close to them). For this purpose a special pile-driver was designed and constructed, as the work had to be done from the inside of the building. Fig. 2 shows a sketch of the rig used. It consisted of a pair of leads connected at intervals by yokes made of bar iron, and fitted with a head frame at the top. In use, the driver rested on a plank flooring laid in the foundation trench. To guide the piles while driving iron bracket bars fastened to the leads at intervals as shown supported 4 × 6-in. timbers, against which the pile was held and which maintained its alinement. The width of the foundation was 4 ft., and piles were spaced 2 ft. along the trench and 18 ins. in a transverse direction. Altogether about 100 new piles were put in.

Both old and new piles were cut off 12 ins. below the top of the old piles as settled, and a solid layer of 12 × 12-in. ranging timbers laid over their tops in the length of the foundation and drift-bolted to the piles. On top of these timbers the brick bearing wall was built up to the first story level, being reinforced under the columns by heavy piers. Four 18-in. I-beams with separators were placed on top of the piers and the column bases wedged to bearing on these beams. Fig. 3 shows the foundation as reconstructed.

The first tier of beams had not been connected to the framework of the building, but rested directly on the bearing wall. These beams had all been removed to make room for the foundation work, and they were replaced in their original position. It was thought advisable on this account to tie together the column bases at the first floor level, and 2-in. tie-rods with turnbuckles were put in for this purpose. The reconstructed work has up to the present proved perfectly satisfactory.

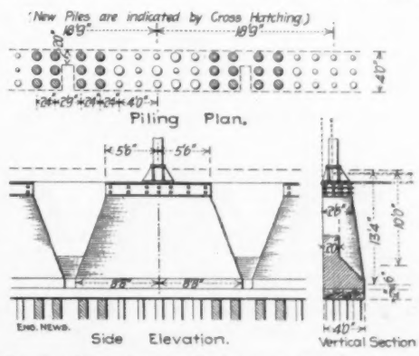


Fig. 3. Reconstructed Foundation of Settled Wall.

It may be noted that when the brickwork was removed preliminary to the reconstruction there was found no sign of damage to the beams or columns, except at one point at the third tier, where a column flange-connection was found to be slightly cracked. The conditions that were found seemed to warrant the belief that this fa-

vorable state of affairs was due to the poor workmanship of the original construction, which produced a structure so deficient in rigidity as to yield without damage to the considerable distortion that accompanied the settlement.

TWO TYPES OF GERMAN HOT-METAL MIXERS.

A recent American design for a hot-metal mixer of large capacity, 325 tons, was illustrated and described in our issue of April 3, 1902. In one of the latest numbers of the "Zeitschrift des Vereins Deutscher Ingenieure" there appear illustrations of two German designs of large hot-metal mixers, which it may be interesting to compare with the one referred to. We therefore reproduce these illustrations, with a short explanation of their main features. It may be mentioned that these drawings represent mixers of which a number have been built in the past year or two, for different German steelworks, and used there with full success.

The hot-metal mixer shown in Fig. 1 is designed for a capacity of 275 tons of fluid metal. The maximum external dimensions of the containing tank are, about, 15 ft. diameter and 27 ft. length. The shape is cylindrical, with a conical pouring spout at the front end, which converges from the full width of the tank to a narrow opening. A charging-funnel is on the top of the tank at the back end. The tank is lined with magnesia bricks to well above the slag-level. The support of the tank is a large pin, of a length equal to about two-thirds the diameter of the tank, resting between two saddle-castings bolted respectively to the tank body and the foundation. A cast chair built into the foundation forms a rest for the heel of the tank when this is tilted back, as shown in the cut. The molten metal is charged into the filling-spout from ladle-cars running on an elevated track back of the mixer. In the case illustrated, an elevator was used to raise the ladle-cars to this level. The metal is run from the mixer into other ladle-cars running on a platform at a lower level, which extends entirely around the mixer. These ladles then run directly to the converters or the furnaces.

For tilting the vessel of the mixer a hydraulic arrangement is provided. A cylinder set vertically below the back end of the vessel has its plunger linked to a bracket-arm fastened to the mixer; the pressure water is taken directly from the water-works system of the plant or is supplied by separate pumps. The valves of the hydraulic cylinder are of the balanced piston type and are operated from the front of the platform,

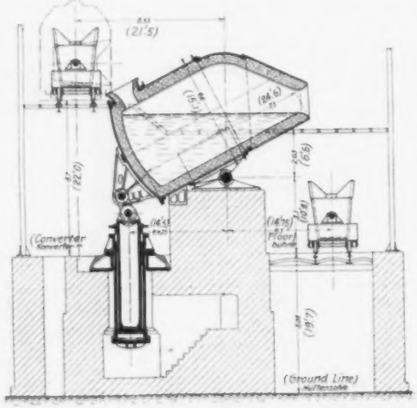


Fig. 1. A German Pivoted Hot-Metal Mixer of 275 Tons Capacity.

so that the filling of the ladles is under the eye of the operator. An easily accessible emergency valve is provided by which the cylinder ports can be closed entirely in case the operating gear should fail to work. Further, the pressure water supply pipe is made so small that if the pipe breaks or the supply fails, the vessel will tilt back to normal position slowly and without dangerous shock.

The mixer shown in Fig. 2 is of the rolling type, and will be seen from the cut to be closely similar to the American mixer above mentioned. It is designed for a capacity of 225 to 250 tons (no dimensions are given on the original cuts from which our illustrations are reproduced). The vessel is composed of steel plates formed in cylindrical and spherical segments, and requires no additional bracing. It is lined all over with best magnesia bricks. The vessel rests on two circular roller beds, each composed of five rollers, supported by pedestal bearings, resting on foundation girders. The roller tracks fastened to the vessel are of cast steel. Concentric with these are two

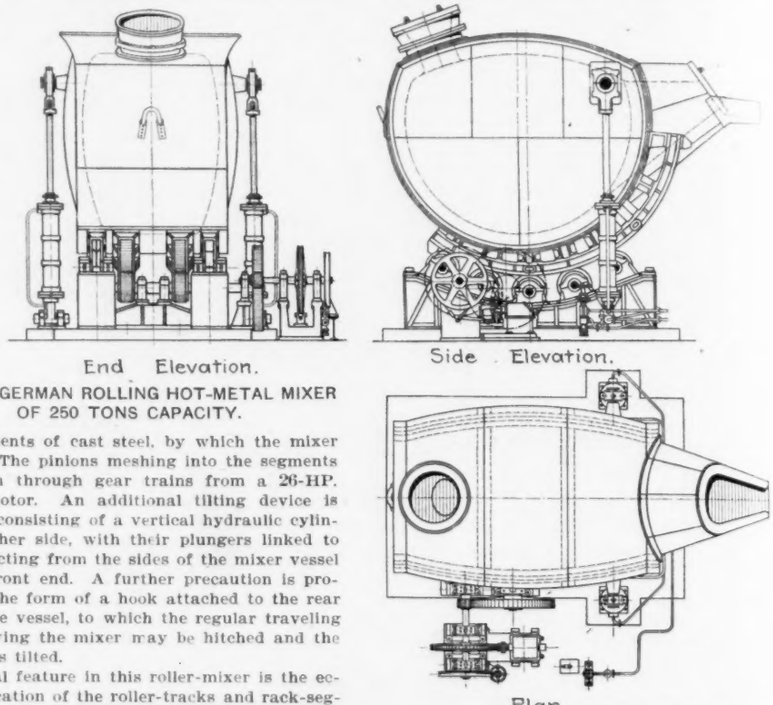


FIG. 2. A GERMAN ROLLING HOT-METAL MIXER OF 250 TONS CAPACITY.

rack segments of cast steel, by which the mixer is tilted. The pinions meshing into the segments are driven through gear trains from a 26-HP. electric motor. An additional tilting device is provided, consisting of a vertical hydraulic cylinder at either side, with their plungers linked to pins projecting from the sides of the mixer vessel near its front end. A further precaution is provided in the form of a hook attached to the rear face of the vessel, to which the regular traveling crane serving the mixer may be hitched and the vessel thus tilted.

A special feature in this roller-mixer is the eccentric location of the roller-tracks and rack-segments; the object of this is that the mixer may tilt back to normal position by its own weight in case of failure of the tilting arrangements. This feature, and the multiplicity of the tilting arrangements, as well as the shape of the vessel itself, are claimed by the builders as special points of advantage of this mixer over similar American designs. The design of this mixer is due to Mr. W. Oswald, of Koblenz. Both the mixers shown are built by the Kölnishe Machine Works Co., of Köln-Bayenthal, Germany.

SOME OBSERVATIONS ON THE DEEP PNEUMATIC WORK OF THE NEW EAST RIVER BRIDGE FOUNDATIONS.

By Edwin Duryea, Jr., M. Am. Soc. C. E.*

In the Engineering News of Sept. 5, 1901, is an editorial, entitled "The Occurrence and Treatment of Caisson Disease in Engineering Works," which has just come to the attention of the writer. As a statement is made in relation to the greatest air pressure used at the New East River Bridge which differs greatly from the fact and as some conclusions are based on this statement, it seems well that the real facts should be explained. The work in question was done under the immediate direction of the writer as Resident Engineer, and he is therefore very familiar with all the facts and conditions. An explanation was begun in the form of a "letter to the editor," but so many interesting points developed that it was thought better to put it in the form of a short general description of some special features of the work. The compressed air conditions met in the two Brooklyn piers were quite unusual and of sufficient interest to merit description, especially as these conditions may be assumed to apply in a greater or less degree to the numerous compressed air tunnels now projected under the East and North rivers. The north pier only will be described, as the conditions met at the south pier were very similar, though it was of somewhat depth.

The editorial states "the work of excavation of placing the concrete (at north Brooklyn New East River Bridge) was performed depth of 108 ft. below water level, requiring air pressure of 46½ lbs. per sq. in." This pressure seems obvious from the depth, except that should be 48 lbs., because of sea water. A matter of fact, however, the highest pressure used in this caisson was 38 lbs. per sq. in., this only when the cutting edge first reached depth of 90 ft. below mean high water. The pressure was then at once reduced to about 31 lbs. per sq. in. for a couple of days; then carried for the remainder of the pneumatic work (a period of over six weeks) at pressures of 33 lbs. to 37 lbs. per sq. in., the variations being irregular and the pressures not increasing with the depth.

The preliminary diamond drill borings showed above the clay about 50 ft. of water and about 20 ft. of sand with some boulders. The clay began at about 70 ft. below mean high water and extended without change to the rock, the highest point of which was found at a depth of 86 ft. and the lowest at a depth of 105 ft. The depths found by the diamond drill were in general corroborated by the more exact information secured during the sinking. This later information showed that unless borings are taken very close to each other no inference is warranted as to the shape of the bed rock at intermediate points, at least with the gneiss rock of this neighborhood. The diamond drill borings and the sinking also showed that no reliance could be placed on wash borings to distinguish between boulders and bed rock. Seven wash borings had been made on and close to the tower site, each boring terminating on stone. A charge of dynamite was exploded in most of these borings, resting directly on the stone, in the hope that if the stone were merely a boulder some shattering or change of position would occur. Subsequent examination showed no such effects, though the diamond drill borings and the sinking revealed the fact that in only one case (and that very doubtful) could the stone located by the wash borings have been anything more than boulders, usually of moderate size, lying on the clay. The possibility of the stone located by the diamond drill borings being merely large boulders was guarded against by carrying each boring about 10 ft. into the rock and securing cores of the same for examination.

With the diamond drill borings as data, the

*1 Broadway, New York city.

caisson, masonry and coffer-dam of the north pier (see Eng. News, May 27, 1897) were designed of such heights as corresponded to a final depth of the cutting edge of 100 ft. below mean high water, or 5 ft. above the deepest known rock. The clay was of such hardness and of so great a depth that entirely suitable foundations for any bridge, except perhaps a suspension bridge, would have been secured by sinking the cutting edge only a few feet into it and not trying to reach the rock. The slightest settlement would affect the verticality of the high tower, however, and as in this case the rock could be reached by the pneumatic process at what was proportionally only a very small addition to the cost of the bridge, the only wise and conservative treatment was to carry the foundations to the rock. In case the rock had been much deeper, it is very probable the clay would have been used as a foundation. It was fully equal for this purpose to the clays on which are founded the truss bridges over the Missouri River at Rulo and Bismarck and the long span cantilever bridge over the Mississippi River at Memphis.

When the caisson of the north pier was landed on the river bottom its cutting edge was about 49 ft. below mean high water. The ordinary fall of the tide was nearly 5 ft. The river bottom was covered by about a foot of very offensive sewer mud, and below this, to a depth of 63 ft. to 72 ft. (average about 68½ ft.), extended a bed of sand, gravel and cobbles, with some boulders. Below this lay a bed of hard, dry stratified clay extending to the rock, the highest point of which was found at a depth of about 84½ ft. and the lowest at 107.5 ft. The average depth of the original rock surface within the whole area of the caisson was 96.5 ft. The maximum depth of 110 ft. which has been published several times is incorrect.

The cutting edge was stopped at a depth of 95 ft. (5 ft. higher than originally intended), 46% of it being then within a few inches of the excavated rock surface and the remainder an average of 7 ft. and an extreme height of 11 ft. above the original rock. The excavated rock surface covered 42% of the area of the caisson. The mean depth of the final rock surface over the whole area of the caisson is 98.3 ft. below mean high water.

The comparatively small amount of work done at the greatest depths is shown by the amount of excavation being only about 2 cu. yds. below the depth of 106 ft., 21 cu. yds. below 104 ft., 77 cu. yds. below 102 ft. and 183 cu. yds. below 100 ft. The size of the caisson was 63 ft. × 79 ft., giving a volume per foot depth for its whole area of 184 cu. yds. The deeper parts were left uncovered as short a time as possible, about 40 cu. yds. of the excavation being done after the concreting was begun. The extreme depth of 107.5 ft. existed for less than an hour, concrete being placed on the rock within a few minutes after it was satisfactorily cleaned.

The indicated air pressure exceeded that corresponding to the depth of cutting edge by several pounds (generally from 3 to 6 lbs) from the beginning down to a depth of about 75 ft., or until all parts of the edge were well within the clay. From this depth to about 90 ft. the two pressures corresponded quite closely, sometimes one and sometimes the other being slightly larger. Below 90 ft., as already mentioned, the indicated pressure was much smaller than that corresponding to the depth of water.

Almost from the beginning the excavation in the middle of the caisson was carried to depths of 6 ft. to 8 ft. below the edge, and this accounts for the excessive pressures carried in the permeable materials above the clay. The advantage of doing the work in this way was that all the excavation could be done below the horizontal struts in the working chamber without interference from them and that the material could be excavated to a large degree from a face. This method could be used only in a broad caisson, as in a narrow one the slopes needed next the edge would leave very little space available for deepening the excavation in the middle.

The sinkages were made intermittently, usually from 3 ft. to 6 ft. in one or two days, after many days spent in preparatory excavation. The maxima were 4 ft. in one day, and at another time 5.9 ft. in two days. Slopes were carried around the edge as long as possible until just before the sinkage.

The question of danger of course arises in carrying excavations below the cutting edge. So long as the pressure maintained is as great as that corresponding to the edge no possible danger can arise from this cause, as the water, even in case of an inburst, will not rise above the level of the edge. Even a somewhat less pressure implies no danger, as it is a common occurrence to allow the water to rise 3 ft. in caisson chambers during a sinkage, the men taking refuge on the beams.

When the excavation is carried 11 ft. vertically below the cutting edge, however, to a depth of 106 ft. below mean high water, and the pressure maintained is not more than 36 lbs. per sq. in., some degree of danger may be thought to have been incurred. The depth corresponding to a pressure of 36 lbs. is 81 ft., or 14 ft. less than the depth of the edge and 25 ft. less than the extreme depth of the vertical clay face. The pressure corresponding to the depth of cutting edge is 42.2 lbs., and that corresponding to the extreme depth of 106 ft. is 47 lbs.

From the information furnished by the borings it was decided that it would be conservative to take advantage of the bed of clay to stop the cutting edge at a height of at least 5 ft. above the deepest rock. This allowed a saving of 5 ft. in both masonry and coffer-dam and a large saving in rock excavation, these savings largely outbalancing the extra cost of the concrete needed to refill the excavation below the cutting edge. As actually built, the edge was stopped 5 ft. higher than intended, or at 95 ft. instead of 100 ft. depth. This resulted in a great saving of time, and also, as the work below a depth of 96 ft. was paid for by the cubic yard, in a further saving of cost to both the city and the contractor. The only change in the construction required by the less depth was the omission of 5 ft. from the coffer-dam and from the masonry below low water, and a considerable addition to the clay excavation and concrete refilling between the elevation of the cutting edge and the rock.

For the south half of the caisson the cutting edge has between it and the rock only a few inches of concrete, while for the north half it has an average intervening depth of 7 ft. and a maximum of 11 ft. This concrete will have an excess pressure from the completed bridge of only about 5 tons per sq. ft., while it might safely, in this location, bear 15 tons. The size of the pier was governed by the lateral dimensions of the tower leg instead of by unit working pressures. The compression which may occur in the extra depth of concrete under the north edge is inappreciable and entirely negligible. The concrete is receiving its load very gradually, as it was placed in 1898, and its full load will not have been reached for at least a year or two to come.

The clay was so impervious that the pressure in the working chamber could easily have been raised to the 47 lbs. per sq. in., corresponding to the maximum depth of 106 ft., or even much higher. The pay and the length of shift of the pressure men were fixed by the depth, and not by the pressure, so carrying a lower pressure than that corresponding to the full depth was of no direct advantage to the contractor, except, perhaps, an inappreciable saving in the cost of air compression. The only reason for using an air pressure less than the depth was a desire to lessen the chances of caisson disease among the men. Experience has shown that the disease is not very prevalent at depths less than 80 ft., corresponding (in fresh water) to pressures less than about 35 lbs. Advantage was therefore taken of the imperviousness of the clay to lower the pressure to about this point. There is no reason to suppose that it could not have been safely lowered much more, but with the unusually short hours of the men there was no object in doing so—besides, a limit must always be placed on such experiments The height of the water inside the coffer-dam was also an element in determining the minimum air pressure. The constant and certain danger to the men from high pressures was prevented and a risk taken in exchange which was less, everything considered, than those usually taken in open excavations.

The only risk possible was in a sudden caving of the vertical bank and an inrush of water. As a matter of fact, the methods and care used obviated practically all risks. As before remarked, slopes were carried around the edge as long as possible and the clay dressed to a vertical face only a comparatively short time before sinking or before concreting. Planks and braces were kept on hand and used in a few places where it seemed advisable. A close watch was kept, and the air pressure could have been increased quickly if necessary. The characteristics of the clay were well known from work at higher levels and in the south pier. In that pier the edge was also 11 ft. above the lowest rock, but the average distance was much less than in the north pier. The maximum pressure carried was 31 lbs., about 5 lbs. less than that corresponding to the depth of cutting edge and 10 lbs. less than that corresponding to the deepest rock.

The clay was very peculiar in its appearance, and quite unusual. It was very uniform and markedly stratified, resembling at a few feet distance a strongly laminated gneiss. It was, in fact, supposed to be a decomposed gneiss rock, until some small boulders were encountered in it. Its junction with the bed rock was plainly marked, only an inch or two of harder material separating them. The clay was free from sand, quite dry, and would absorb very little water, though by continued working it would become greasy and putty-like. It was so hard that it was found economical to excavate a great deal of it by blasting with dynamite, though it was not impracticable to excavate it by pick and bar. Vertical faces were soon affected by exposure to the air, pieces varying in size from a pail to a barrel detaching themselves slowly. This was easily prevented, where necessary, by planks.

The quality of the clay, its soundness—the stratification showing that it had not been disturbed since its original deposition—and its great thickness would have justified risks much greater than any taken. The minimum thickness of clay above the edge was 23 ft., and this was overlaid by a minimum thickness of 36 ft. of sand and excavated materials. No water was ever found leaking down from between the outside surface of the caisson and the clay.

In sand it is impracticable to do any work cheaply at a lower depth than the cutting edge, as the water is very sensitive to changes of pressure, and while in sand it is not possible to raise the pressure very much above that corresponding to the edge. When concreting on a sand foundation, it is often necessary to raise the pressure as high as may be in order to drive the water down in the sand and secure a dry bottom for the concrete. This was necessary in most of the sand foundations of the Cairo Bridge, the excess pressure being there usually 2 or 3 and in one case 5 lbs.

In clay, on the other hand, some work always has to be done below the edge. No sinkage can be made until the clay has been excavated vertically for the full depth of the proposed settlement, and this is done without increasing the air pressure. In one of the piers of the Rulo Bridge a test well was sunk through clay 17 ft. below the edge without any increase in the pressure. A 4-ft. vein of gravel was then struck, when the pressure had to be at once increased 8 to 10 lbs. When the well was refilled the pressure was lowered to its former amount. At the Memphis Bridge test wells were sunk in each of the five pneumatic piers from 2 to 15 ft. below the edge in clay without any corresponding increases in pressure.

While working with pressures less than the depth is unusual in bridge piers, it is quite common in tunnels built with compressed air, where much reliance is often placed on the imperviousness and strength of the overlying materials and the compressed air is used largely as a safeguard and aid. The distinction between tunnels and bridge piers in this respect is that in the former no intentional connection exists between the tun-

nel and the water of river, while in the case of the latter the process of sinking necessarily makes a connection, more or less closed by shifting materials, between the working chamber and the river.

It is seen from the facts given that while work was done at a great depth in the New East River Bridge piers, they cannot be classed among structures where high pressures were used.

The most familiar example of high pressures is the St. Louis Bridge, where the sinking was through sand to rock. The east pier, when landed on rock, had its cutting edge immersed 93.2 ft., corresponding to over 40 lbs. per sq. in. The last 34 ft. was sunk in 27 days, or at an average rate of 15 ins. per day. Filling of the chamber with concrete was begun seven days later and discontinued after 38 days, when the immersion had reached a depth of 111.75 ft. The concreting was resumed after an intermission of 28 days, the river having fallen to an immersion of 107½ ft., and was completed 16 days later. The concreting of chamber lasted 53 working days (in two disconnected periods), and was done in pressures of 45 lbs. to 50 lbs., corresponding to theoretical immersions of about 104 ft. to 115 ft.

The only other deep sinking at the St. Louis Bridge was the sinking of the east abutment. When its cutting edge was 14.9 ft. above rock, with an immersion of 97.3 ft., the pressure carried was 43 lbs. Nine days later, with its edge 10.1 ft. above rock, an immersion of 101.1 ft. and a pressure of 46 lbs., the work was stopped by a tornado. After an interval of eight days, the sinking was resumed and rock was reached twelve days later. When landed on the rock the edge was immersed 109.7 ft. and the pressure was 49 lbs. Two days later the placing of concrete under the edge and girders was begun and completed in 17 days. The remainder of the chamber was then pumped full of sand and water.

The most notable and successful instance among bridge foundations of long protracted continuous work under heavy pressures is the sinking of the two river piers of the Memphis Bridge, though but little attention seems to have been drawn to it. This work was done by day's labor under the direction of Mr. Alfred Noble as Resident Engineer. The piers are on clay foundations, and were sunk through sand and a few feet into the clay. In Pier II. the immersion of edge was for 11 days from 100 ft. to 104 ft., with indicated pressures of 41 lbs to 43 lbs. and calculated pressures of 43 lbs. to 45 lbs. At a later period the immersion was from 93 ft. to 104 ft. for 50 days, the indicated pressures being 40½ lbs. to 44½ lbs. and the calculated 40½ lbs. to 45 lbs. In Pier III. the immersion was for 21 days from 90 ft. to 105 ft., with indicated pressures of 37 lbs. to 44½ lbs. and calculated pressures of 39 lbs. to 45½ lbs. For 75 days at a later time the immersion was 94 ft. to 106.4 ft., with the indicated and calculated pressures respectively 40 lbs. to 47 lbs. and 41 lbs. to 46 lbs.

An interesting observation of temperatures was made at the south Brooklyn pier of the New East River Bridge. This was done in the middle of June, while concreting the working chamber, with the air pressure 31 lbs. per sq. in. The air lock was located about 20 ft. above the cutting edge at the foot of a deep damp 6-ft. shaft, and communicated alternately with this shaft and with the working chamber. The temperature of the lock just after "bringing it in" was + 95° F., and just after "taking it out" + 67°; the general temperature of the working chamber was by observation + 81°. Air was being delivered to the chamber at this time through two pipes, the regular pipe carrying cooled air and a smaller pipe carrying air which had not been cooled. The temperature at the exit of the cold air pipe was + 77° and at the hot air pipe + 90°. The time of bringing in the lock was probably about 3 mins. and of taking it out about 5 mins. The observation is unfortunately incomplete in not including these times and the general temperatures at the foot of the shaft and in the external air.

The air was cooled by passing it through a collection of 1-in. gas pipes (aggregating about 500 ft. in length) immersed in the river, and not by spraying. The same method had been used at Cairo, Memphis and elsewhere. The question of cooling the air for the north pier was unimportant, as the chamber of this pier was concreted in November.

The great immunity from caisson disease of the pressure men employed at great depths on the Brooklyn piers was due to three causes—to the pressure used being much less than that corresponding to the depth; to the length of shift being unusually short even for the full depth and still more so for the actual pressure, and to the use of an elevator in raising the men to the surface.

The deepest work was done with the edge at a depth of 95 ft. below mean high water and with the lowest rock under the edge at a depth of 106 ft. The pressure actually used, however, corresponded to a depth of only about 83 ft. (of fresh water). The corresponding hours worked were 1½ hours per 24 hours, divided into two shifts of ¾ hours each, with an interval of 4½ hours to 6 hours between shifts. This schedule applied to all work below 90 ft. depth, the hours for depths of 80 ft. to 90 ft. being two shifts of 1 hour each, with 4 hours' rest between.

The schedules at the Memphis and Bellefontaine bridges were usually as follows: 80 ft. to 90 ft. depth, two shifts of 2 hours each; below 90 ft. depth, three shifts of 1 hour each At the Rulo Bridge two shifts of 1½ hours each, were used between 80 ft. and 90 ft. The schedule at the Cairo Bridge was generally two shifts of 2 hours each for depths below 80 ft. (80-95), with 10 hours' rest between; the shifts were in some cases reduced to 1½ hours each. The inspectors of concreting in the chamber of the north Brooklyn pier (all young engineers) worked two shifts of 1 hour each, or longer than the pressure men; and the writer and some others at times spent an aggregate of three or four hours per day in the pressure, taking extra shifts. The solicitude of the pressure men for our health was touching but unconvincing, as most of them had worked on the Western bridges mentioned.

Fifty-Ton, Stiff-Leg, Steel Derrick at the Docks of the Cornell Steam Boat Co., Rondout, N. Y.

American Hoist & Derrick Co., St. Paul, Minn., Builders.

The use of an elevator for the men has been spoken of as a great safeguard against caisson disease. It is probably one of the most important in deep work, personal experience having shown that a climb up a ladder in a damp 3-ft. shaft, sometimes a hundred feet or more in depth, just after leaving the pressure, is a more exhausting task than the work in the air chamber. The climb is probably less enervating when made in compressed air, with the lock at the top of shaft, but for many reasons the bottom lock seems usually preferable. The use of elevators is not important when the depths are less than about 80 ft. Their use in connection with deep work should not be regarded as an extra expense, as the more effective work of the men when no long climb is anticipated will probably more than counterbalance their cost. Cooling of the air is very important in summer and in hot climates.

The habits of pressure men have a great deal to do with the prevalence of caisson disease. The high pay, short hours of work and period of idleness between shifts (generally not long enough to allow of going far from the work) all conduce toward the spending of much of the idle time in saloons, and to too much drinking and too little sleep. A "sand-hog" ball is generally followed by a greater prevalence of "bends" among the men.

An elevator was used at the east abutment of the St. Louis Bridge, and one was also used at both the Memphis and the Bellefontaine bridges. At the Brooklyn piers of the New East River Bridge the elevator shaft was 6 ft. in diameter and the inside diameter of the elevator itself was 5.4 ft. The elevator would hold 18 large men, estimated at the time to average 170 lbs. each, making an average load per sq. ft. of its floor of about 134 lbs. The 6-ft. diameter lock would hold 20 men and allow the door to open inward. The men were in both cases very tightly packed.

Much more might be written about the Brooklyn piers, but this is intended as a description of some special points only. The piers were built by the Degnon-McLean Construction Co., and the success attending the difficult pneumatic work was due principally to the good judgment and untiring watchfulness of J. E. Taber, their foreman in general charge of the sinking.

FIFTY-TON STIFF-LEG STEEL DERRICK FOR CORNELL STEAM BOAT CO., RONDOUT, N. Y.

The accompanying illustration shows a stiff-leg steel derrick of 50 tons capacity and 85 ft. radius of boom which was recently installed at the docks of the Cornell Steamboat Co., at Rondout, N. Y., for loading and unloading boats and transferring freight between them and the cars of the Delaware & Hudson Canal Co. The illustration shows the derrick under the application of the test load of 50 tons, consisting of two boilers filled with water.

An interesting feature of this derrick is that it is constructed entirely of steel. Briefly described, it has a latticed steel mast and boom supported by two latticed steel stiff legs, all substantially anchored to a pile and concrete foundation. The boom has an effective radius of 85 ft., and swings three-quarters of a circle. It will be noted that the construction of the boom was such that no truss rods were used, as they would have met with interference, owing to the crowded surroundings of the dock. All castings were made of "Tropenas steel," possessing a tensile strength of from 70,000 to 80,000 lbs. per sq. in. All sheaves were turned and bronze-bushed and they run on center-bored axles. The boom line is seven-ply and the hoisting line eight-ply plow steel cable ¾-in. in diameter, and 2,000 ft. of line are employed.

The derrick is swung by the old-fashioned tag-line method, since the location in this case was such that ground space could not be provided for a suitable power-slewing device. In reference to this construction, the makers write us as follows:

> We concede that a heavy derrick of this character should certainly be revolved by power, but in this instance it was not easily accomplished, and the requirements of the derrick were such that it was not essential. Extra precautions were taken to pivot the mast truly so that it would swing with the minimum effort.

The hoisting operations are performed by a double-cylinder, double-drum hoisting engine, with 10 × 12-in. cylinders and drums 16 ins. in diameter and 4 ft. below flanges. The gears are 60 ins. in diameter, with 7-in. faces, and are arranged in the ratio of 5.7 to 1. With this ratio and diameter the normal single line strain is 14,000 lbs. The bed area of the hoist is approximately 7 × 12 ft., and it operates with a nominal strain pressure of 150 lbs. Each drum has a friction operated by screw and hand-wheel.

The derrick was sold and erected by the New York office of the American Hoist & Derrick Co., and was constructed at the works of that company at St. Paul, Minn. The approximate cost of the completed derrick is stated to have been $12,000. We are indebted to the builders for the information from which this description has been prepared.